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# Teaching Science in Five Countries:

## Results From the TIMSS 1999 Video Study

## Statistical Analysis Report

**U.S. Department of Education**
Institute of Education Sciences
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# 1 Chapter 1
## Introduction

This report presents the results of a study of eighth-grade science teaching, conducted as part of the Third International Mathematics and Science Study (TIMSS) 1999 Video Study.[1] The Video Study is a supplement to the TIMSS 1999 student assessment, a successor to the TIMSS 1995 student assessment.[2] The TIMSS 1999 Video Study had the broad purpose of investigating and describing teaching practices in eighth-grade mathematics and science in a variety of countries.[3] Results for the science portion are presented in this report and in a summary document entitled *Highlights From the TIMSS 1999 Video Study of Eighth-Grade Science Teaching* (Roth et al. 2006).

The TIMSS 1999 Video Study of science teaching included the participation of five countries: Australia, the Czech Republic, Japan, the Netherlands, and the United States. It had the following broad objectives:

- Develop objective, observable measures of classroom instruction that can be quantified appropriately to develop indicators of eighth-grade science teaching practices in each country;
- Describe patterns of science teaching practices within each country; and
- Compare science teaching practices between countries and identify similarities and differences in lesson features across countries, with a focus on differences between higher- and lower-achieving countries.

Building on the interest generated by the TIMSS 1995 Video Study of mathematics teaching, the TIMSS 1999 Video Study of mathematics and science teaching had a final objective regarding effective use of the information:

- To develop methods for communicating the results of the study, through written reports and video cases, for both research and professional development purposes.

The TIMSS 1999 Video Study was funded by the National Center for Education Statistics (NCES), the former Office of Educational Research and Improvement of the U.S. Department of Education, and the National Science Foundation (NSF). It was conducted under the auspices of the International Association for the Evaluation

[1] Since the 2003 administration, TIMSS is now known as the Trends in International Mathematics and Science Study.

[2] The TIMSS student assessments were conducted in 1994-95, in 1998-99, and again in 2003. For convenience, reference will be made to the student assessments as TIMSS 1995, TIMSS 1999, and TIMSS 2003 throughout the remainder of the report. In other documents, TIMSS 1999 is referred to as TIMSS-R (TIMSS-Repeat). The supplementary video studies will be referred to as the TIMSS 1995 Video Study and the TIMSS 1999 Video Study.

[3] The results for the mathematics portion were presented in a report titled *Teaching Mathematics in Seven Countries* (Hiebert et al. 2003) with an accompanying technical report (Jacobs et al. 2003).

of Educational Achievement (IEA), based in Amsterdam, the Netherlands. Support for the project was also provided by each participating country through the services of a research coordinator who guided the sampling and recruiting of participating teachers. In addition, Australia contributed direct financial support for data collection and processing of its respective sample of lessons.

The current report focuses on the findings of the TIMSS 1999 Video Study of science teaching with brief descriptions of the methods used (see appendix A). A supplementary technical report that only addresses additional details specific to the science portion of the TIMSS 1999 Video Study will be released separately (Garnier et al. forthcoming). A brief description of the methods used for sampling, questionnaire development, video data coding, and statistical analyses is provided in appendix A and a list of participants is provided in appendix B of this report. In some cases, definitions of constructs and variables that appear in the report are included in appendix D.

This chapter describes the rationale for the study and provides an overview of the conceptual framework, coding dimensions, and guiding principles used in developing valid and reliable codes for the analyses of the science lessons. The chapter highlights the importance of international comparisons of teaching and the use of video in this process. The overview of the science conceptual framework highlights the importance of developing a shared language that links terms and concepts about science teaching with actual classroom images of science teaching.

## Why Study Science Teaching in Different Countries?

There are at least four reasons to study science teaching in different countries and to select countries that have historically achieved at a variety of levels.

- ***Identify alternatives:*** Comparative studies of science teaching can suggest alternative ways of teaching science. Such country variations were found in both the TIMSS 1995 (Stigler et al. 1999) and the TIMSS 1999 Video Studies of mathematics teaching (Hiebert et al. 2003). No single method of teaching eighth-grade mathematics was observed across the relatively higher achieving countries in the study but significant variations were found. Detecting variations across countries with higher achievement may reveal alternative choices in the teaching of eighth grade science. Similar discoveries may emerge from comparative study of eighth grade science teaching.
- ***Reveal one's own science teaching practices more clearly:*** Comparative studies, like the TIMSS 1995 and 1999 Video Studies, can reveal taken-for-granted and hidden aspects of science teaching (Stigler, Gallimore, and Hiebert 2000; Stigler and Hiebert 1999). Seeing one's own practices is a first step toward re-examining them (Carver and Scheier 1981; Tharp and Gallimore 1989), and ultimately improving them.
- ***Stimulate discussion about choices within each country:*** Importing practices wholesale from one cultural context to another is likely to be problematic (Stigler and Hiebert 1999). However, comparing practices across cultures, and uncovering alternative practices, can underscore the idea that classroom practices are the result of choices rather than inevitabilities. Choices made in the past can be re-examined from a fresh perspective, and may be a stimulus to discussion about ways to improve teaching.

- ***Deepen educators' understanding of teaching and students' opportunities to learn science:*** Cross-cultural studies of teaching provide information about different systems of teaching, including different ways in which the basic ingredients of teaching can be configured (Stigler, Gallimore, and Hiebert 2000) and different kinds of opportunities for student learning that can be provided. Comparative studies of science lessons can help researchers construct hypotheses about effective science teaching practices and then use these hypotheses to guide future research.

## How Should Science Teaching Across Countries Be Described?

The TIMSS 1999 Video Study of science teaching analyzed 439 eighth-grade science lessons to produce descriptions and comparisons of science teaching in five different countries. In the science education community, a video data set of this size and international scope has never before been collected and analyzed. To accomplish this challenging task, the development of coding strategies for an international team of coders was needed that would generate valid and reliable descriptions of science teaching.

### Guiding Conceptual Framework

Multiple approaches were taken to organize and prioritize study goals, research questions, and coding dimensions. First, analysis of field test lesson videos by an international team of researchers (the Science Code Development Team) led to hypotheses about important features of science teaching in each of the participating countries. Next, an extensive literature review, including analyses of research studies as well as standards and curriculum documents from each of the participating countries (American Association for the Advancement of Science (AAAS) 1990, 1993; Australian Education Council 1994; Czech Ministry of Education 1996; Dutch Ministry of Education, Culture, and Science 1998; Kolavova 1998; Ministry of Education, Science, and Culture [*Monbusho*] 1999; National Research Council (NRC) 1996; Nelesovska and Spalcilova 1998) provided an exhaustive list of features of science teaching that might be investigated in the study.[4] This led to the development of a brainstormed list of possible research questions and associated lesson features to identify in the videos. Five U.S. science educators serving as advisors to the project and a national research coordinator from each of the five participating countries then reviewed and prioritized the nominated research questions and coding dimensions. Finally, the Science Code Development Team, which included representatives from each of the participating countries, compared the important features of science teaching emerging from the literature review, the advisors' recommendations of high priority lesson features to examine, and their own review of lessons from the dataset to develop an overarching conceptual framework and a set of research questions that guided decisions about coding priorities as well as the organization of the presentation of the results in this report.

[4] Of the five participating countries, three have national curricula (the Czech Republic, Japan, and the Netherlands). Australia and the United States do not have national curricula; rather, decisions regarding curricula are taken at the state, provincial, or local level. Reference is made throughout this report to standards, curricular guidelines and reform documents from each of the countries. In the case of the Czech Republic, Japan, and the Netherlands, these are the official documents that guide classroom teaching and learning decisions. In Australia and the United States, these documents are produced by large national professional and scientific organizations that promote standards and improvement for science teaching and learning. However, these documents should not be construed as official or definitive statements of national, state, provincial or local governments in these two countries. Rather, they represent the most widely referenced and distributed curricular and standards documents available in these two countries.

**FIGURE 1.1. TIMSS 1999 Video Study: Science conceptual framework**

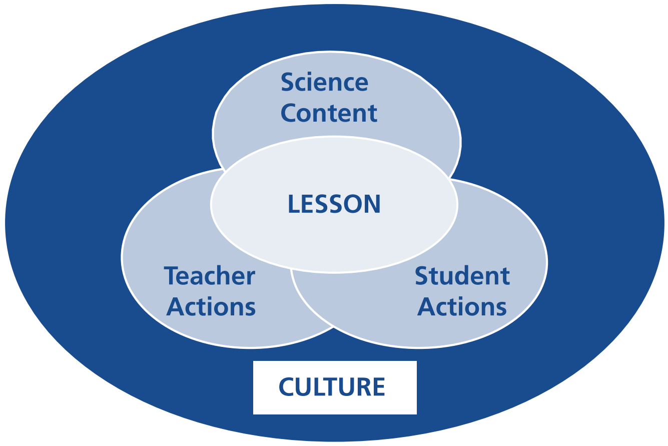



Figure 1.1 presents the conceptual framework for the TIMSS 1999 Video Study analysis of science lessons. The TIMSS conceptual framework emphasizes the centrality of the lesson as the unit of analysis in this study and emphasizes the importance of capturing aspects of all of Schwab's four commonplaces of teaching — the teacher, the learners, the subject matter, and the social milieu (Schwab 1969, 1971, 1973). There was strong consensus among the study's advisors and national research coordinators that the study not be limited to identifying teacher actions; there must also be an examination of the science content and the students' actions and opportunities for learning. Thus, teaching is more than the teacher's actions — it is an interaction among the teacher's actions, the students' actions, and the science content.

The important influence of the larger culture on all aspects of the science lesson is also emphasized in the conceptual framework. To say science teaching is a cultural activity means that teaching is situated in a bed of routines, traditions, beliefs, expectations, and values of students, teachers, administrators, parents, and the interested public (Gallimore 1996). For example, research demonstrates that teachers have deeply held beliefs about their students, about teaching and learning, about their roles as teachers, and about science (Carlsen 1991; Clark and Peterson 1986; Cronin-Jones 1991; Gallagher 1994; Hollon, Anderson, and Roth 1991: Martens 1992; Olson 1981; Pajares 1992). These beliefs can influence how teachers represent science in their classrooms and the kinds of opportunities they provide for students to learn about science. In this study, cultural differences will not be directly observed but will be revealed through unique country patterns that emerge from observations of the teachers, students, and science content in the lessons.

While the framework acknowledges the importance of Schwab's four commonplaces of teaching, analysis of each of these aspects of teaching is limited to observable features related to the teacher, the students, and the science content which are then used to describe country patterns of teaching. The teacher and student focus, for example, is on their observed actions rather than on important but unobservable activities such as teachers' decision making processes or teachers' or students' understanding of the science content. Although the study focuses primarily on features of science teaching that are observable in the videotapes, information about teachers' background, planning practices, and goals are included in in-depth teacher questionnaires (see chapter 2).

## Guiding Research Questions

The main research question guiding the conceptual framework was: What opportunities did the lesson provide for students to learn science? As shown in table 1.1, the main research question was supported by three guiding questions to examine students' opportunities to learn in each of the three areas represented in the conceptual framework—teacher actions, science content, and student actions. Each guiding question was then explored through a set of four to fourteen more specific questions and codes. Although this is a study of classroom teaching, the focus of analysis was placed on students and the ways in which teaching decisions provided different kinds of opportunities for students to learn science. This focus on student opportunity to learn fits well with the research literature on student thinking and learning, and with one of the key stimuli for the study—the differences in student achievement as evidenced on TIMSS 1995 and 1999 assessments (Martin et al. 2000).

## Developing a Shared Language for Describing and Comparing Science Teaching in Five Countries

Comparative studies of teaching pose many challenges. One is development of a shared understanding of the terms and concepts to describe and compare teaching across countries. As demonstrated in a recent study of science lessons (Matsubara et al. 2002), even experts see science teaching differently. Like research on teaching in other fields, science education research typically describes teaching in words without links to images of practice. Science educators may use common terms (such as inquiry teaching or constructivist teaching), but that does not guarantee the words refer to identical practices.

Using videos to study teaching offers another way to develop a shared language (Stigler, Gallimore, and Hiebert 2000). Videos allow investigators to view and review teaching events many times in order to develop a shared set of referents for terms and definitions that are linked to images. This is especially crucial in a study involving multiple languages and countries, especially during the code development phase. In addition, video facilitates the study of complex processes, by permitting investigators to parse data analysis into more manageable portions. Observers can code video in multiple passes, coding different dimensions of science teaching in each pass. This same quality increases inter-rater reliability, and decreases training difficulties. Researchers from different locations and different cultural and linguistic backgrounds can work together, in the same geographic location, to develop codes and establish their reliability using a common set of video data. Video enables coding from multiple perspectives, allowing researchers with different areas of expertise and points of view to examine the same lessons. Although videotaping classroom lessons brings its own challenges, the method has significant advantages over other means of recording data for investigating teaching. Extended discussions of video as a tool in teaching research are available elsewhere (Hiebert et al. 2003; Stigler, Gallimore, and Hiebert 2000; Stigler and Hiebert 1999).

To accomplish the goal of a shared language grounded in images of science teaching, the research team developed a set of guiding principles for the code development process. These principles are:

- ***Involve cultural insiders in the code development and coding process:*** The Science Code Development Team included representatives from each participating country. In addition, National Research Coordinators, high level educational researchers and leaders in their respective

**TABLE 1.1. Research questions for the TIMSS 1999 Video Study of Science Teaching**

| Main research question | What opportunities did the lesson provide for students to learn science? |
|---|---|
| Teacher Actions: Instructional Organization (Chapter 3) | How did the teacher organize the lesson to support students' opportunities to learn science?<br><br>• How much time was spent studying science?<br>• How was the lesson organized for different instructional purposes?<br>• How was the lesson organized for practical and seatwork activities?<br>• How was the lesson organized for whole-class and independent work? |
| Science Content (Chapters 4-6) | How was science represented to students in the lesson?<br><br>• Which scientific disciplines and topics were addressed in the lessons?<br>• What types of science knowledge were addressed in the lessons?<br>• What was the source of the science content and its organization?<br>• How much science content was in the lesson?<br>• How coherent was the science content?<br>• How challenging was the science content?<br>• What types of evidence were used to develop science content ideas in the lesson?<br>• Were main ideas supported with multiple sources of evidence? |
| Student Actions (Chapters 7- 11) | What opportunities did students have to participate in science learning activities?<br>• What were the features of independent practical activities?<br>• What science inquiry actions did students practice during independent work and during whole-class work?<br>• How much did students work in pairs or groups versus individually?<br>• What features characterized students' collaboration during group work?<br>• Did students have opportunities to talk about science?<br>• Did students have opportunities to write about science?<br>• Did students have opportunities to read about science?<br>• Did students have different kinds of opportunities to communicate science?<br>• Did lessons include relevant issues for students?<br>• Did lessons involve students in hands-on, practical work?<br>• Did lessons involve students in motivating activities?<br>• Did lessons use different strategies to engage students?<br>• What responsibilities did students have during the lesson?<br>• What responsibilities did students have outside the lesson? |

SOURCE: U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study, Video Study, 1999.

countries, were consulted at key points during the code development process. After code development, the codes were applied by the International Video Coding Team that included at least two representatives from each country.

- ***Involve scientists in the code development process:*** The Science Code Development Team, a team of science consultants, and Steering Committee members with science backgrounds representing the fields of biology, chemistry, geology, and physics helped develop and review codes. In addition, a team of science experts representing the different science disciplines helped develop codes and code the lessons for science content features (the Science Content Coding Team).

- ***Involve teachers and teacher educators in the code development process:*** The code development team included experienced science teachers and teacher educators. In addition, teachers were consulted to review and give input to the development of specific codes.

- ***Employ an iterative process of code development:*** Once the conceptual framework, research questions, and coding priorities had been identified (as described previously in the Guiding Conceptual Framework and Guiding Research Questions sections), the next step in the code development process was to organize the prioritized coding dimensions into sets of lesson features that could be coded by video analysts in one viewing of the lesson. For example, Dimension 1 focused on identifying the beginning and end of the lesson and segments of time devoted to science instruction, classroom organization, and non-science activities, while Dimension 10 included a cluster of lesson features related to the science content, its coherence, and level of complexity. Focusing on one set of lesson features, the Science Code Development Team first reviewed a few lessons qualitatively, with each member proposing strategies for capturing the selected lesson features. Descriptions for each code were developed collaboratively as the group watched and discussed video examples together. Science Code Development Team members then independently applied the proposed definitions to a new lesson(s). Afterwards, the group compared their independent coding decisions and used differences in opinion as a strategy for clarifying the written definitions and for reviewing the effectiveness of the proposed codes in capturing the desired lesson feature. This process of independent review of lessons followed by group review and consensus building continued until 85 percent or higher inter-rater agreement was reached by the Science Code Development Team members or until a decision was made to drop, revise, or create new codes. Once the team established inter-rater agreement, the coding manual was finalized and the team coded one lesson from each country to serve as "masters" to use in reliability tests for the coding teams (the International Video Coding Team and the Science Content Coding Team). Across a two- and one-half-year period, the International Video Coding Team and the Science Content coding Team examined the lessons to code for 11 different dimensions.

- ***Create multiple-layered, concrete descriptions and definitions from loosely defined pedagogical principles***: Pedagogical principles that are complex and difficult to define, such as inquiry teaching or practical work, were coded in stages. In the first stage, for example, coders marked all segments of the lesson that engaged students in doing hands-on, practical science work. In the second stage, these segments were revisited to consider whether students engaged in various inquiry activities before, during, or after each hands-on segment. In yet another stage, codes were developed about the type of hands-on activity (e.g., model building, observation of phenomena, classification, controlled experiment, etc.). These specific codes were used to create a concrete picture of various aspects of inquiry and practical work that were observed in the lessons.

- ***Use codes that capture occurrences of events, duration of events, characteristics of events, and quality of events.*** Achieving inter-rater agreement in a study of this type is challenging because of the complexity of classroom events, the large number of videotapes being analyzed, the cultural differences in the science lessons, and the international make up of the main coding team. It is easier, of course, to get inter-rater agreement when simply marking the occurrence of clearly observable events (e.g., use of science notebooks, assignment of homework, and student-initiated questions). To create a more complicated view of the lessons, the coding teams:
  - Used detailed procedures to identify events that are not easily observable.

    The number of main ideas in the lesson is an example of a lesson feature that was not easily observed. To make such difficult observations reliably, the content coding team followed a detailed procedure that included first marking all the ideas presented in the lesson and then looking for ideas that the teacher explicitly linked together to identify sets of ideas that hung together around one main idea.
  - Identified the duration as well as the occurrence of some events.

    To capture the length of time spent on different kinds of lesson events, many lesson features were marked with in- and out-points. For example, the time spent on examining real-world issues, the time spent on independent practical activities, and the time spent on organizational matters was identified.
  - Described the characteristics of events.

    Follow-up questions about many of the identified lesson events enabled the coder to describe the characteristics of the lesson event. For example, when students were coded as writing, a follow-up question asked about the type of writing that students were doing (copying notes, providing one-word or multiple choice responses, generating a sentence-length response, and generating a paragraph-long response).
  - Judged the overall quality of selected events.

    Overall judgment codes were applied to a limited set of content-related codes by science experts. For example, overall quality judgments were made about the content coherence of the lesson and the level of content complexity in the lesson.

## What Are the Methods for Studying Teaching in Different Countries?

A brief description of the methods used for sampling the participating countries and the science lessons, developing codes to be applied to the videotaped lessons, and establishing code reliability follows. More detailed information can be found in appendix A and the TIMSS 1999 Video Study technical report (Garnier et al. forthcoming).

### Selection of Countries

The TIMSS 1999 Video Study extended the 1995 study that explored whether eighth-grade teachers in higher-achieving countries taught mathematics in similar ways by including more higher-achieving countries and including eighth-grade science teaching. The selection of the participating countries was based on the results of the TIMSS 1995 assessments. The TIMSS 1999 and 2003 science assessments were administered after the TIMSS 1999 Video Study was underway and played no role in the selection of countries for the Video Study. Table 1.2 lists the countries that participated in the TIMSS 1999 Video Study of eighth-grade science along with their average scores on TIMSS 1995, 1999, and 2003 science student assessments. On the TIMSS 1995 science assessment, eighth-grade students in Japan and the Czech Republic performed significantly above the other three countries. Students in the United States performed significantly below all four of the other countries. In 1995 and again in 1999, eighth-grade students in the United States scored, on average, significantly lower than their peers in the other four countries. Since that time, however, the U.S. experienced a significant improvement in average science performance at grade 8. In 2003, U.S. students' average score in science was not measurably different from the average score in Australia and the Netherlands, but remained significantly below the average score of Japanese students. The Czech Republic did not participate in TIMSS 2003.

**TABLE 1.2. Average science scale scores of eighth-grade students, by country: 1995, 1999, and 2003**

| | 1995 | | 1999 | | 2003 | |
|---|---|---|---|---|---|---|
| Country | Average score | Standard error | Average score | Standard error | Average score | Standard error |
| Australia[1] | 527[1] | 4.0 | 540 | 4.4 | 527 | 3.8 |
| Czech Republic | 555 | 4.5 | 539 | 4.2 | — | — |
| Japan | 554 | 1.8 | 550 | 2.2 | 552 | 1.7 |
| Netherlands[1] | 541[1] | 6.0 | 545 | 6.9 | 536 | 3.1 |
| United States[2] | 513 | 5.6 | 515 | 4.6 | 527 | 3.1 |

[1]Nation did not meet international sampling and/or other guidelines in 1995. See Beaton et al. (1996) for details.
[2]Nation did not meet international sampling and/or other guidelines in 2003. See Gonzales et al. (2004) for details.
—Not available. The Czech Republic did not participate in the 2003 assessment.
NOTE: Rescaled TIMSS 1995 science scores are reported here (Gonzales et al. 2000). The average for Australia in 2003 cannot be compared to the averages in 1995 and 1999 due to national level changes in the starting age/date for school. The 1995 and 1999 averages are those reported in Gonzales et al. 2000. The 2003 average is the one reported in Gonzales et al. 2004.
SOURCE: Gonzales, P., Calsyn, C., Jocelyn, L., Mak, K., Kastberg, D., Arafeh, S., Williams, T., and Tsen, W. (2000). *Pursuing Excellence: Comparisons of International Eighth-Grade Mathematics and Science Achievement from a U.S. Perspective, 1995 and 1999* (NCES 2001– 028). Washington, DC: Government Printing Office. Gonzales, P., Guzman, J.C., Partelow, L., Pahlke, E., Jocelyn, L., Kastberg, D., et al. (2004). Highlights From the Trends in International Mathematics and Science Study (TIMSS) 2003 (NCES 2005-005) Washington, DC: Government Printing Office.

## Selection of Lessons

The methods followed to select the science lessons to be videotaped in each of the participating countries was based on the standards and procedures agreed to and implemented for the TIMSS 1999 assessments (Martin, Gregory, and Stemler 2000). The sample of schools drawn for the study within each country was required to be a probability proportionate to size (PPS) sample. Using this method, the probability of a school being selected was proportional to the number of eligible students in the eighth-grade in schools countrywide. Each randomly selected school submitted a list of the science classes offered for eighth-graders. From this list, one science class per school was randomly selected to be videotaped. The goal was to videotape 100 randomly selected eighth-grade science lessons in each participating country. The participation rate of schools in the study ranged from 81 to 100 percent (weighted, with replacement schools).

No substitutions of teachers or class periods were allowed. The randomly selected eighth-grade science class was videotaped once, in its entirety, without regard to the science topic being taught or the type of activity taking place. The only exception was that teachers were not videotaped on days they planned to give a test or examination for the entire class period.

Science lessons were videotaped throughout a regular school year, making accommodations for how academic years were organized in each country. This allowed for the collection of science lessons that, because they were evenly distributed over the school year, likely represented the topics and activities that eighth-graders would encounter during a regular academic school year. Detailed information on sampling and participation rates is included in appendix A and in the forthcoming technical report (Garnier and Rust forthcoming).

## Code Development

Three teams were assembled to develop and apply codes that would capture teaching activities and behaviors to the video data (see appendix B for list of team and advisory group members). The Science Code Development Team included science specialists, researchers, and representatives from each of the participating countries. This team was responsible for developing codes, writing coding manuals, training coders, and tracking reliability. They discussed coding ideas, created code definitions, wrote a coding manual, gathered examples and practice materials, designed a coder training program, trained coders and established reliability, organized quality control measures, consulted on difficult coding decisions, and managed the analyses and write-up of the data. To help identify and develop codes, the Science Code Development Team worked closely with two advisory groups consisting of national research coordinators representing each of the countries in the study and a steering committee of five North American science education researchers.

The International Video Coding Team represented all of the participating countries and the members were fluent in the language of the lessons they coded. This team coded lessons for features that did not require science content expertise.

The Science Content Coding Team consisted of U.S. experts in science content (including biology, physics, chemistry, and geology). This team coded for features that required science content knowledge. Their primary responsibility was to apply a series of codes to all of the scientific content of the videotaped lessons. The codes included the nature of scientific topics, types of science knowledge, level of difficulty of the science content, and different modes of content development. The science content coders also assisted the code development team in making revisions to the coding manual that improved coding reliability.

## Code Reliability

Developing and applying codes to observations of science teaching requires clear reliability procedures to ensure consistency and accuracy. Extensive training for the International Video Coding Team was the first step and critical since they came from different countries with a variety of backgrounds. Reliability was established for three types of video codes that were applied by this team. These codes identified whether an activity or behavior occurred and measured how long the activity or behavior took place. Coders marked the videotapes on category, in-point, and out-point of the activity or behavior. The consistency of the different coders applying the same codes to the same behaviors was measured with percentage agreement between the coders within and across countries. Percentage agreement was estimated by dividing the number of agreements by the number of agreements plus disagreements. The codes were evaluated at the beginning and midpoint of the coding process for each coding dimension (see appendix A for more details on the reliability of each code). The minimum acceptable reliability estimate for all coders, averaging across countries, was 85 percent. Additional training was provided until an acceptable level was achieved for coders not meeting the minimum acceptable criterion. Codes that did not demonstrate minimum acceptable reliability after multiple attempts were dropped from the study. For selected codes, consensus coding was used. Two coders independently coded a lesson and then met to reconcile any differences in their coding decisions. The procedures used to measure reliability are described in Bakeman and Gottman (1997). The members of the Science Content Coding Team each established reliability through consensus coding of all the team members.

## Limitations of the Study

### Sample of Participating Countries

The sample of countries participating in the TIMSS 1999 Science Video Study includes five countries. The four relatively higher-achieving countries may not be representative of all the countries with students performing well on international assessments of science. The one relatively lower-achieving country, the United States, ranks higher than some other countries with lower average student performance on international assessments (Gonzales et al. 2000, 2004). National policy changes implemented after the data collection also may be associated with changes in teaching in the science classrooms.

### Coverage of Topics

The lessons in the TIMSS 1999 Science Video Study cover a wide range of topics drawn from the science disciplines of biology, chemistry, earth science, health, physical science, and technology.[5] Because of the range of content and the small number of lessons collected on any given topic (e.g., electricity) or even within a given science discipline, descriptions in this report can focus on the average experience of eighth-grade students in their classroom science lessons. That is, it is not possible to describe the average chemistry or physics lesson in the eighth-grade, for example. This is an important limitation, since some of the differences observed in science teaching practice across countries may be an artifact of the disciplines emphasized. Thus, the observation that some countries use more first-hand observations of phenomena during science lessons may be explained either by country differences in science teaching practices or by differences in the science discipline that is being taught at the eighth grade. At grade 8, Australia, Japan, and the United States offer science as a single general or integrated subject; in the Czech Republic and the Netherlands, grade 8 science is offered through separate subject courses in physics, chemistry, life science, and earth science (Martin et al. 2000).

### Student Behaviors

A video study of eighth-grade science teaching is limited to a subset of factors that may affect student achievement. While the TIMSS 1999 Science Video Study focused on recording and interpreting a complex set of teaching practices, reliably capturing some student behaviors and characteristics was not feasible. Student behaviors and characteristics, such as being “on task” or being motivated and

[5] The science discipline “Technology” includes the nature of technology, interaction of science, mathematics, and technology, and the history of science and technology.

ready to learn, would require a high level of inference. Differences may be so subtle and culturally bound as to make it impossible to reliably code such behaviors from video data.

## Caution About Drawing Inferences With Student Achievement

No direct inferences can or should be made to link descriptions of teaching in the TIMSS 1999 Video Study with students' levels of achievement as documented by TIMSS assessments. The relationships between classroom teaching and learning are complicated. While there is evidence that teaching makes a difference in students' learning (Brophy and Good 1986; Hiebert 1999; NRC 2000), eighth-graders' science achievement is the culmination of many factors and many years spent both inside and outside of school (Floden 2001; NRC 2000; Wittrock 1986). Moreover, such inferences are not warranted because in most of the participating countries, the videotaped classrooms were not the same ones in which students took the achievement tests. Furthermore, even if student assessment data were available to link to video-based indicators, it would be unwise to use data from a single lesson to assess the impact of teachers' instructional practices on student learning outcomes. The sampling frame was a random selection of lessons meant to represent the practices within a country and not to obtain a reliable estimate of the average practice of an individual teacher.

The descriptions of science classroom lessons in this report reveal a complex variety of features and patterns of teaching. Countries are similar to, and different from, each other in interesting and sometimes subtle ways. Interpretation of these results requires a thoughtful and analytic approach. This study looked at common patterns of science teaching shared by the participating high-achieving countries, but did not attempt to identify which specific practices are related to higher student achievement.

The purpose of this report is to introduce new NCES survey data through the presentation of selected descriptive information. Readers are cautioned not to draw causal inferences based solely on the bivariate results presented. It is important to note that many of the variables examined in this report are related to one another, and complex interactions and relationships have not been explored here. Release of the report is intended to make the information available to the public and encourage more in-depth analysis of the data.

## What Can Be Found in This Report?

The presentation of results is organized around the conceptual framework and the three guiding research questions (figure 1.1 and table 1.1). After a presentation of the context of the lessons as reported by the participating teachers on a questionnaire (chapter 2), the focus is placed on the teacher's organization of the lesson (chapter 3).

Chapters 4–6 describe how science content is represented to students in the lesson. Chapter 4 presents the content topics and knowledge types addressed in the science lessons, while chapter 5 describes the density, coherence, organization, and challenge of the science content. Chapter 6 explores the ways in which the science ideas are supported by evidence in the form of data, phenomena, or visual representations. Together, these chapters examine how lessons provide students with opportunities to understand science as a set of ideas.

Chapters 7–11 present different aspects of students' opportunities to participate in learning science. In chapter 7, the attention focuses on students' opportunities to engage in doing practical work and to use selected science inquiry behaviors. Students' opportunities to collaborate in carrying out science activities are examined in chapter 8. Chapter 9 explores student and teacher communication about science. The ways in which science is presented as interesting and relevant to students' lives are presented in chapter 10, while chapter 11 examines the ways in which students are expected to take responsibility for their own learning.

The report concludes by describing observable country patterns of science teaching, based on the analyses presented in this report, and a consideration of inferences that may be drawn from the patterns evident across the countries and across the various lesson features (chapter 12).

For all analyses presented in this report, differences between averages or percentages that are statistically significant are discussed using comparative terms such as "higher" and "lower." Generally, differences that are not found to be statistically significant are either not discussed or referred to as "no measurable differences found." Failure to find a statistically significant difference should not be interpreted to mean that the estimates are the same or similar; rather, failure to find a difference may be due to sampling or measurement error. To determine whether differences reported are statistically significant, ANOVAs and two-tailed *t*-tests, at the .05 level of significance, were used. When more than two groups were compared simultaneously (e.g., a comparison among all five countries), the significance tests were based on a Bonferroni procedure for multiple comparisons that holds to 5 percent probability of erroneously declaring the mean of one country to be different from another country. The analyses were weighted with survey weights developed specifically for this study. They were needed to produce estimates that are unbiased estimates of national means and distributions. The weight for each classroom reflects the overall probability of selection for that classroom, with appropriate adjustments for non-response (see Rust forthcoming for a more detailed description of weighting procedures). In some cases, large apparent differences in data are not significant due to large standard errors, small sample sizes, or both. Standard errors for all estimates displayed in the figures and tables in the report are included in appendix C.

In some cases, the reported estimates are marked with an exclamation point (!). This indicates that the estimate is unstable. Unstable estimates were identified by calculating the coefficient of variation (CV), by dividing the standard error of the estimate by the estimate. Estimates are marked as unstable in all cases in which the CV was found to be .50 or greater.

To assist readers in interpreting data presented in tables and figures, results of the statistical tests are listed below each table and figure in which data are compared. Results are indicated by the use of the greater than (>) symbol and three-letter country codes, e.g., AUS>CZE, meaning that Australia's average is greater than the Czech Republic's average. Only those comparisons that were determined to be significant ($p \leq .05$) are listed.

Accompanying the printed version of this report is a CD-ROM on which are presented short video clips that illustrate many of the codes used to analyze the lesson videos. For the United States and the Czech Republic, the video clips are taken from lessons filmed specifically for the purpose of public display. These lessons were not included in the sample analyzed for this report. For Japan and Australia, video clips are taken from lessons collected for the TIMSS 1999 Video Study. For the

Netherlands, some lessons were filmed specifically for the purpose of public display, while others were taken from the sample collected for the TIMSS 1999 Video Study. In all cases, permission to display the video clips was granted by all participants or their legal guardians. The CD-ROM is entitled "Teaching Science in Five Countries: Video Clip Examples." In chapters 3–11 of the published version of this report, a camera icon ( ) and note is provided that indicates the number of the video clip on the CD-ROM relevant to the discussion. For the CD-ROM version of this report, a hyperlink to the relevant example is provided.

In addition to this report, highlights from the study are published in a separate document, entitled *Highlights From the TIMSS 1999 Video Study of Eighth-Grade Science Teaching* (Roth et al. 2006; NCES 2006-017), and five full-length lesson videos from each of the five participating countries are available on CD-ROM discs. These 25 public-release videos are presented as a set of CD-ROMs and include, in addition to lesson videos, accompanying materials with a transcript in English and the native language, as well as commentaries by teachers, researchers, and national research coordinators in English and the native language. These public release videos and materials are intended to augment the research findings, support teacher professional development programs, and encourage public discussion of teaching and how to improve it.

All of the products related to the TIMSS 1999 Video Study can be accessed or ordered by going to the NCES web site (http://nces.ed.gov/timss).

# 2 Chapter 2
## Context of the Lessons

This chapter presents background information on the videotaped teachers and the context of the lessons based on teachers' responses to a questionnaire after their science lessons were videotaped. Analyses of their responses to questionnaire items help assess the typicality of the videotaped lesson and of the sample of teachers who participated in the study. Questionnaire data were obtained from teachers in 100 percent of the eighth-grade science lessons videotaped in Australia, the Czech Republic, and Japan, 98 percent of the Dutch lessons, and 95 percent of the U.S. lessons.

More information on teacher response rates, as well as the development of the questionnaires and how they were coded, can be found in appendix A and in the technical report (Garnier forthcoming).

The context of an eighth-grade science lesson is defined by, among other things, characteristics of the teachers, their expectations for science teaching and learning, their current ideas about teaching and learning science, and where the lesson fits in the curricular sequence. To collect information on these factors, questionnaire items addressed the following three questions:

- What are teachers' background experiences and workloads?
- What factors do teachers report as influencing the content of the lessons?
- What are teachers' perceptions of the typicality of the lessons?

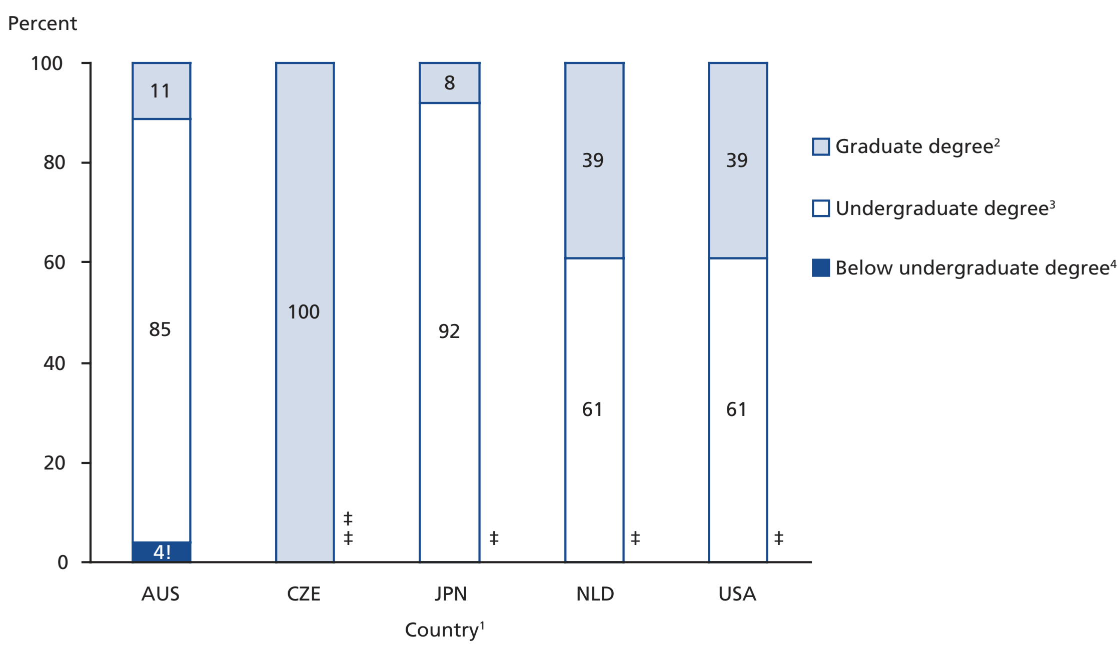
### What Are Teachers' Background Experiences and Workloads?

Science teachers bring a variety of educational and professional experiences to the classes they teach. These experiences can influence their planning and implementation of a lesson (National Research Council (NRC) 2001). To better understand the eighth-grade science lessons taught by teachers who participated in the video study, data were collected on teachers' educational preparation, professional background, and current teaching responsibilities. When interpreting results, the reader should keep in mind that some results could be influenced by national requirements or support, which can vary by country. Information on the measures used can be found in appendix D.

## Educational Preparation

- Teacher reports indicated that the average eighth-grade science lesson in each of the five countries was taught by a teacher with, at a minimum, postsecondary education in science or science education and certification to teach eighth-grade science. Figure 2.1 shows that at least 96 percent of the eighth-grade science lessons in the five countries were taught by teachers who attained at least an undergraduate degree or the equivalent. All of the Czech lessons were taught by teachers who reported that they had attained graduate degrees, a larger proportion of lessons than in all other countries, ranging from 8 to 39 percent. At least 98 percent of the eighth-grade science lessons in all of the participating countries except the United States were taught by teachers who were certified to teach science in eighth-grade or grades higher than eighth grade (data not shown).
- Ten percent of U.S. eighth-grade science lessons were taught by teachers who reported they were certified to teach science only in grades lower than eighth grade.
- As table 2.1 indicates, fewer eighth-grade science lessons in the United States were taught by teachers who majored in one or more areas of science (64 percent) compared to lessons in the other countries (87 to 100 percent). Furthermore more U.S. lessons were taught by teachers who majored in areas other than science, such as general education (36 percent), compared to Australia and Czech lessons (13 and 5 percent, respectively).

**FIGURE 2.1. Percentage distribution of eighth-grade science lessons, by teacher's highest level of education and country: 1999**




!Interpret data with caution. Estimate is unstable.
‡Reporting standards not met. Too few cases to be reported.
[1] AUS=Australia; CZE=Czech Republic; JPN=Japan; NLD=Netherlands; and USA=United States.
[2] Graduate degree: CZE>AUS, JPN, NLD, USA; NLD, USA>AUS, JPN.
[3] Undergraduate degree: AUS, JPN, NLD, USA>CZE; AUS, JPN>NLD, USA.
[4] Below undergraduate degree: No measurable differences detected.
NOTE: Results based on the classification of science teachers' reports of their educational attainment according to the International Standard Classification of Education (ISCED) (OECD 1997).
SOURCE: U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study, Video Study, 1999.

**TABLE 2.1. Percentage of eighth-grade science lessons, by teacher's undergraduate or graduate major and country: 1999**

| Major area of study | Australia (AUS) | Czech Republic (CZE) | Japan (JPN) | Netherlands (NLD) | United States (USA) |
|---|---|---|---|---|---|
| Science[1] – Total | 87 | 95 | 100 | 99 | 64 |
| Life sciences[2] | 47 | 48 | 20 | 41 | 46 |
| Physics[3] | 15 | 33 | 30 | 44 | ‡ |
| Chemistry[4] | 29 | 32 | 31 | 37 | 4 |
| Earth sciences[5] | 11 | 48 | 10 | 6! | 6 |
| General science[6] | 4! | ‡ | 100 | ‡ | 11 |
| Other than science[7] | 13 | 5 | ‡ | ‡ | 36 |

!Interpret data with caution. Estimate is unstable.
‡Reporting standards not met. Too few cases to be reported.
[1]Science: AUS, CZE, JPN, NLD>USA; JPN, NLD>AUS.
[2]Life sciences: AUS, CZE, USA>JPN.
[3]Physics: JPN, NLD>AUS.
[4]Chemistry: AUS, CZE, JPN, NLD>USA.
[5]Earth sciences: CZE>AUS, JPN, NLD, USA.
[6]General science: JPN>AUS, USA.
[7]Other than science: USA>AUS, CZE.
NOTE: Results based on science teachers' reports. Science includes teachers' response to any of the fields of science: life science, physics, chemistry, earth science, and general science. Teachers were free to define "major area" and to mention as many areas of study that applied. Areas of study include life sciences, physics, chemistry, earth sciences, general sciences, and other area of study. Since teachers could list more than one area for undergraduate and graduate studies, the percentages presented in table 2.1 could add to more than 100 percent within a country.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study, Video Study, 1999.

- On average, eighth-grade science lessons in the Czech Republic were taught by teachers who reported more experience teaching in general (21 years) and teaching science specifically (19 years) compared to lessons in the other four countries (ranging from 12 to 15 years teaching, in general, and 10 to 14 years teaching science; table 2.2).

**TABLE 2.2. Summary and dispersion measures for eighth grade science teachers' teaching experience,by country: 1999**

| Teaching experience | Australia (AUS) | Czech Republic (CZE) | Japan (JPN) | Netherlands (NLD) | United States (USA) |
|---|---|---|---|---|---|
| Years teaching | | | | | |
| Mean[1] | 15 | 21 | 15 | 14 | 12 |
| Median | 16 | 21 | 15 | 11 | 7 |
| Range | 0-39 | 1-41 | 1-34 | 1-36 | 1-35 |
| Years teaching science | | | | | |
| Mean[2] | 14 | 19 | 14 | 12 | 10 |
| Median | 15 | 18 | 15 | 9 | 7 |
| Range | 0-39 | 1-39 | 1-34 | 1-33 | 1-35 |

[1] Mean years teaching: CZE>AUS, JPN, NLD, USA.
[2] Mean years teaching science: CZE>AUS, JPN, NLD, USA.
NOTE: Results based on science teachers' reports. Mean years per country are calculated as the sum of the number of years reported by teachers divided by the number of lessons within a country. For each country, the median is calculated as the number of years below which 50 percent of the lessons fall. Range describes the lowest number of years and the highest number of years reported within a country. A response of zero (0) indicates that a teacher was in the first year of teaching at the time of data collection.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study, Video Study, 1999.

## Professional Development Opportunities

- Teachers typically participated in some professional development activities in all five of the countries, but varied in the types of activities in which they participated. Between 38 and 56 percent of lessons in all the countries except Australia were taught by teachers who took additional science or science education courses in the two years prior to the videotaping (table 2.3).

- The most frequently identified professional development activities included the use of technology, science instructional techniques, and standards-based teaching (table 2.4). More Australian, Dutch, and U.S. eighth-grade science lessons were taught by teachers who identified the use of technology (79, 68, and 84 percent, respectively) compared to lessons in the Czech Republic and Japan (45 and 42 percent, respectively). More U.S. science lessons were taught by teachers who participated in activities related to science instructional techniques (66 percent) compared to lessons in Australia (36 percent) and the Czech Republic (36 percent), and participated in standards-based teaching (52 percent) compared to the Netherlands (22 percent).

**TABLE 2.3. Percentage of eighth-grade science lessons taught by teachers who participated in science-related education courses, and the average number of professional development activities teachers participated in the 2 years prior to data collection, by country: 1999**

| Country | Percentage of lessons taught by teachers who took at least one science or science education course[1] | Average number of professional development activities[2] |
|---|---|---|
| Australia (AUS) | 9 | 3 |
| Czech Republic (CZE) | 56 | 2 |
| Japan (JPN) | 38 | 2 |
| Netherlands (NLD) | 50 | 2 |
| United States (USA) | 49 | 5 |

[1] Courses: CZE, JPN, NLD, USA>AUS.
[2] Professional development activities: AUS>CZE, JPN, NLD; NLD>JPN; USA>AUS, CZE, JPN, NLD.
NOTE: Results based on science teachers' reports of professional development activities in the two years prior to data collection. Average number of professional development activities calculated as the sum of the number of professional development activities divided by the number of lessons within a country.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study, Video Study, 1999.

## Time Spent on Different School Activities

- Table 2.5 shows that across all the countries, eighth-grade science lessons were taught by teachers who reported spending an average of 38 to 45 total hours per week on teaching and other school-related activities. At least a third of this time was spent teaching science classes. Teachers of Japanese science lessons reported spending less time, on average, teaching other classes and working at home on science teaching related matters compared to teachers in the other four countries. Teachers of Dutch science lessons spent less time doing work at school related to teaching science compared to teachers of the science lessons in the other four countries.

**TABLE 2.4. Percentage of eighth-grade science lessons, by teachers' participation in professional development activities or academic courses and country: 1999**

| Professional development activity | Australia (AUS) | CzechRepublic (CZE) | Japan (JPN) | Netherlands (NLD) | United States (USA) |
|---|---|---|---|---|---|
| Classroom management and organization[1] | 37 | 6 | 19 | 16 | 21 |
| Cooperative group instruction[2] | 29 | 7 | 12 | 36 | 48 |
| Interdisciplinary instruction[3] | 14 | 5 | ‡ | 3 | 48 |
| Science instructional techniques[4] | 36 | 36 | 50 | 43 | 66 |
| Standards-based teaching[5] | 36 | — | 29 | 22 | 52 |
| Teaching higher-order thinking skills[6] | 22 | ‡ | ‡ | 11 | 44 |
| Teaching students from different cultural backgrounds[7] | 13 | ‡ | ‡ | 8 | 31 |
| Teaching students with limited proficiency in their national language[8] | 5 | ‡ | ‡ | 5! | 18 |
| Teaching students with special needs[9] | 23 | 7 | 6 | 12 | 36 |
| Use of technology[10] | 79 | 45 | 42 | 68 | 84 |
| Other professional development activities[11] | 46 | 42 | 18 | 25 | 44 |

—Not available.
‡Reporting standards not met. Too few cases to be reported.
[1] Classroom management and organization: AUS, USA>CZE.
[2] Cooperative group instruction: AUS, NLD, USA>CZE; NLD, USA>JPN.
[3] Interdisciplinary instruction: USA>AUS, CZE, NLD.
[4] Science instructional techniques: USA>AUS, CZE.
[5] Standards-based teaching: USA>NLD.
[6] Teaching higher-order thinking skills: USA>AUS, NLD.
[7] Teaching students from different cultural backgrounds: USA>AUS, NLD.
[8] Teaching students with limited proficiency in their national language: No measurable differences detected.
[9] Teaching students with special needs: AUS>JPN; USA>CZE, JPN, NLD.
[10] Use of technology: AUS, NLD, USA>CZE, JPN.
[11] Other professional development activities: AUS, CZE, USA>JPN.
NOTE: Results based on science teachers' reports of participation in professional development or academic coursework in the two years prior to the videotaping of lessons. Totals do not sum to 100 because more than one category could be selected. The option "standards-based teaching" was not appropriate for the Czech Republic and was excluded from the questionnaires and analyses. Use of technology includes but is not limited to using computers.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study, Video Study, 1999.

TABLE 2.5. Average weekly hours eighth-grade science teachers reported spending on teaching and other school-related activities, by country: 1999

| Activity | Australia (AUS) | Czech Republic (CZE) | Japan (JPN) | Netherlands (NLD) | United States (USA) |
|---|---|---|---|---|---|
| All teaching and other school-related activities– Total[1] | 38 | 42 | 40 | 40 | 45 |
| Teaching science classes[2] | 14 | 16 | 16 | 19 | 20 |
| Teaching other classes[3] | 3 | 6 | 1 | 4 | 4 |
| Meeting with other teachers to work on curriculum and planning issues[4] | 2 | 1 | 1 | 1 | 2 |
| Work at school related to teaching science[5] | 7 | 6 | 6 | 4 | 7 |
| Work at home related to teaching science[6] | 6 | 6 | 4 | 7 | 6 |
| Other school-related activities[7] | 5 | 7 | 12 | 5 | 6 |

[1] All teaching and other school related activities: No measurable differences detected.
[2] Teaching science classes: JPN, NLD, USA>AUS; NLD>CZE.
[3] Teaching other classes: AUS, CZE, NLD, USA>JPN; CZE>AUS.
[4] Meeting with other teachers to work on curriculum and planning issues: USA>CZE, JPN.
[5] Work at school related to teaching science: AUS, CZE, JPN, USA>NLD.
[6] Work at home related to teaching science: AUS, CZE, NLD, USA>JPN.
[7] Other school-related activities: JPN>AUS, CZE, NLD, USA.
NOTE: Results based on science teachers' reports. Hours may not sum to totals because of rounding. Average hours per week calculated by the sum of hours for each lesson divided by the number of lessons within a country.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study, Video Study, 1999.

## What Do Teachers Report as Influencing the Content of the Lessons?

Teachers' decisions about what and how they teach are associated with many factors including their learning goals for students, curriculum guidelines, mandated textbooks, standardized tests, cooperative work with other teachers, and teachers' awareness of current ideas about teaching and learning science. The following section presents the eighth-grade science teachers' descriptions of factors that they perceive as having influenced the content taught in the videotaped lesson as well as their satisfaction in achieving lesson goals. Teachers provided responses after the lesson was videotaped.

### Teachers' Learning Goals for Science Lessons

- More Czech eighth-grade science lessons were taught by teachers whose stated goals for the videotaped lessons were knowing science information compared to lessons in the other four countries (table 2.6). Teachers of more Australian and Japanese science lessons identified the lesson goal as understanding scientific ideas in comparison with the United States and the Czech Republic.
- Within Australia and Japan, more science lessons were taught by teachers who indicated they wanted students to understand scientific ideas than teachers who wanted students to know science information (table 2.6). On the other hand, within the Czech Republic, more science

lessons were taught by teachers who wanted students to know science information than teachers who wanted students to understand scientific ideas.

## Teachers' Decisions to Teach the Content of the Lesson

- In addition to their learning goals, teachers reported that the content of the videotaped lesson was influenced by a variety of factors that varied across countries. Curriculum guidelines were identified by teachers as a major influence on their decisions about lesson content in more Czech and U.S. science lessons than in the other three countries. Mandated textbooks were reported by teachers as playing a major role in more Czech and Dutch science lessons than in Australian and U.S. science lessons, and in more Japanese science lessons than in U.S. science lessons (table 2.7).
- Curriculum guidelines were reported by teachers as playing a major role in their decisions in more Czech and U.S. science lessons compared to Australian, Japanese, and Dutch science lessons (table 2.7). Also, in the U.S. science lessons, more teachers identified students' interests or needs compared to all the other countries.
- Within the Netherlands and Japan, more lessons were taught by teachers who indicated that the mandated textbook was a major influence on the videotaped lessons than all or almost all other available options, including teacher's assessment of students' needs in Japan. Within Australia, the Czech Republic, and the United States, more eighth-grade science lessons were taught by teachers who indicated that curriculum guidelines were major influences on the videotaped lessons than were taught by teachers who indicated that cooperative work with other teachers, the mandated textbook, and teacher's comfort with or interest in the topic were major influences (table 2.7). More U.S. lessons were taught by teachers who identified curriculum guidelines as a major influence compared to external examinations, and more U.S. lessons were taught by teachers who identified students' interest or needs as a major influence compared to all other available options except curriculum guidelines.

## Lesson Goals Achieved in the Classroom

- Although a majority of science lessons were taught by teachers who stated that they were satisfied that the videotaped lessons achieved their goals, fewer eighth-grade science lessons in Japan were taught by teachers who reported that they were satisfied that their lessons played out as they had intended (62 percent) compared to the other four participating countries (ranging from 87 to 94 percent) (data not shown).

## Teachers' Awareness of Current Ideas About Teaching and Learning Science

- More Australian, Dutch, and U.S. eighth-grade science lessons were taught by teachers who reported they were familiar with "current ideas" of teaching science than science lessons in the Czech Republic and Japan (figure 2.2). At least 85 percent of science lessons in all the countries, except Japan, were taught by teachers who believed the videotaped lesson was at least "a little" in accord with current ideas (figure 2.3).

**TABLE 2.6.** **Percentage of eighth-grade science lessons, by teacher-identified goals and country: 1999**

| Goal for videotaped lesson | Australia (AUS) | Czech Republic (CZE) | Japan (JPN) | Netherlands (NLD) | United States (USA) |
|---|---|---|---|---|---|
| Knowing and understanding science | | | | | |
| Knowing science information[1] | 20 | 59 | 14 | 23 | 23 |
| Understanding scientific ideas[2] | 51 | 7 | 70 | 27 | 23 |
| Understanding the nature of science[3] | 4! | ‡ | ‡ | ‡ | 4! |
| Doing science | | | | | |
| Carrying out a scientific experiment, project, or activity[4] | 4! | 6 | 10 | 15 | 17 |
| Developing generic thinking skills[5] | ‡ | ‡ | 3! | 8 | 5! |
| Learning laboratory skills[6] | 11 | 10 | 15 | 12 | 6 |
| Using scientific inquiry skills[7] | 13 | 6 | 8 | 11 | 22 |
| Context of science | | | | | |
| Awareness of the usefulness of science in life[8] | 19 | 12 | 9 | 17 | 22 |
| Collaborative work in group[9] | ‡ | ‡ | ‡ | 10 | 8 |
| Independent work[10] | 5 | ‡ | 3! | 11 | 7 |

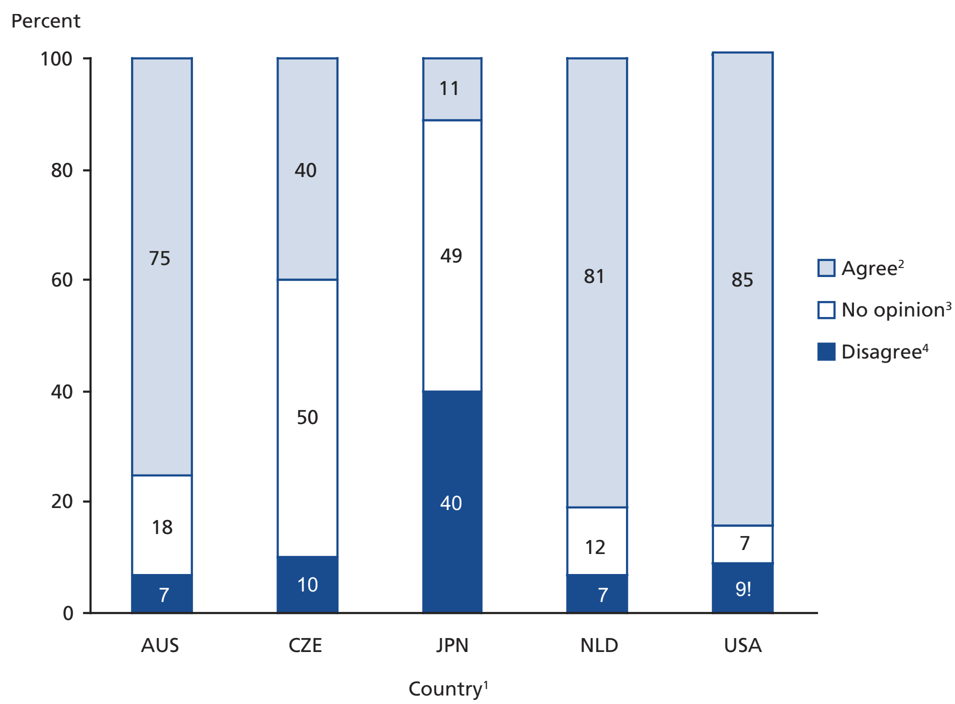
!Interpret data with caution. Estimate is unstable.
‡Reporting standards not met. Too few cases to be reported.
[1] Knowing science information: CZE>AUS, JPN, NLD, USA.
[2] Understanding scientific ideas: AUS, JPN, NLD, USA >CZE; AUS>USA; JPN>NLD, USA.
[3] Understanding the nature of science: No measurable differences detected.
[4] Carrying out a scientific experiment, project, or activity: No differences detected.
[5] Developing generic thinking skills: No measurable differences detected.
[6] Learning laboratory skills: No measurable differences detected.
[7] Using scientific inquiry skills: No measurable differences detected.
[8] Awareness of the usefulness of science in life: No measurable differences detected.
[9] Collaborative work in groups: No measurable differences detected.
[10] Independent work: No measurable differences detected.
NOTE: Results based on science teachers' reports. Totals do not sum to 100 because teacher responses could be coded into more than one goal for the videotaped lesson. Only those goals which were identified by a sufficient number of teachers in at least two countries to produce reliable estimates are included.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study, Video Study, 1999.

**TABLE 2.7. Percentage of eighth-grade science lessons taught by teachers who reported various factors played a "major role" in their decision to teach the content in the videotaped lesson, by country: 1999**

| Factor | Australia (AUS) | Czech Republic (CZE) | Japan (JPN) | Netherlands (NLD) | United States (USA) |
|---|---|---|---|---|---|
| Cooperative work with other teachers[1] | 32 | 6 | 5! | 44 | 25 |
| Curriculum guidelines[2] | 60 | 93 | 20 | 41 | 84 |
| External examinations or standardized tests[3] | — | 3! | 5! | 7 | 23 |
| Mandated textbook[4] | 32 | 67 | 52 | 74 | 26 |
| Teacher's comfort with or interest in the topic[5] | 27 | 47 | 15 | 37 | 41 |
| Teacher's assessment ofstudents' interests or needs[6] | 47 | 39 | 44 | 25 | 74 |

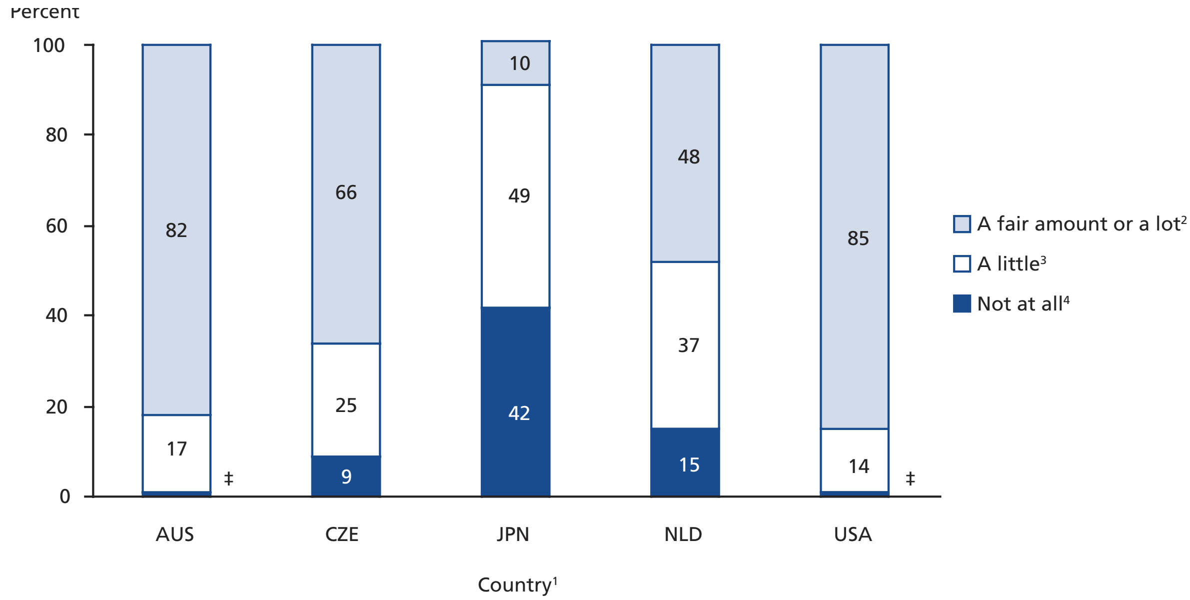
—Not available.
!Interpret data with caution. Estimate is unstable.
[1] Cooperative work with other teachers: AUS, NLD, USA>CZE, JPN.
[2] Curriculum guidelines: CZE, USA>AUS, JPN, NLD; AUS>JPN.
[3] External examinations or standardized tests: USA>CZE, JPN, NLD.
[4] Mandated textbook: CZE, NLD>AUS, USA; JPN>USA.
[5] Teacher's comfort: CZE, NLD, USA>JPN.
[6] Teacher's assessment of students' needs: USA>AUS, CZE, JPN, NLD.
NOTE: Results based on science teachers' reports. Totals do not sum to 100 because more than one category could be selected. The option "external examinations or standardized tests" was not appropriate for Australia and was excluded from the questionnaires and analyses.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study, Video Study, 1999.

**FIGURE 2.2. Percentage distribution of eighth-grade science lessons taught by teachers who reported being familiar with current ideas in science teaching and learning, by country: 1999**




!Interpret data with caution. Estimate is unstable.
[1] AUS=Australia; CZE=Czech Republic; JPN=Japan; NLD=Netherlands; and USA=United States.
[2] Agree: AUS, NLD, USA>CZE, JPN; CZE>JPN.
[3] No opinion: CZE, JPN>AUS, NLD, USA.
[4] Disagree: JPN>AUS, CZE, NLD, USA.
NOTE: Results based on science teachers' reports. Totals may not sum to 100 because of rounding.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study, Video Study, 1999.

**FIGURE 2.3.** **Percentage distribution of eighth-grade science lessons taught by teachers who rated the extent to which the videotaped lesson was in accord with current ideas about teaching and learning science, by country: 1999**




‡Reporting standards not met. Too few cases to be reported.
[1]AUS=Australia; CZE=Czech Republic; JPN=Japan; NLD=Netherlands; and USA=United States.
[2]A fair amount or a lot: AUS, CZE, NLD, USA>JPN; AUS, USA>NLD.
[3]A little: JPN>AUS, CZE, USA.
[4]Not at all: JPN>CZE, NLD.
NOTE: Results based on science teachers' reports. Totals may not sum to 100 because of rounding and data not reported.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study, Video Study, 1999.

## What Are Teachers' Perceptions of the Typicality of the Lessons?

### Typicality of the Course

- Teachers were asked if all students in the school took the videotaped course. In all Dutch eighth-grade science lessons, eighth-grade science teachers responded that all students in the school were required to take the science course that was videotaped (data not shown). In the four remaining countries, between 84 and 97 percent of lessons were in schools that required all eighth-graders to take the videotaped science course.

### Typicality of the Videotaped Lesson

- The videotaped lesson, as perceived by teachers of the eighth-grade science lessons, generally provided a typical picture of everyday classroom instruction with regard to teaching methods (figure 2.4).
- Teachers' descriptions of their students' behavior also indicated that, overall, the lessons captured on the videotapes were typical of their usual behavior (data not shown). Between 68 percent and 77 percent of the science lessons in each country were taught by teachers who reported that the students behaved about the same as usual except in the Czech Republic (51 percent; data not shown).

- The difficulty of the lesson content in 81 to 91 percent of the videotaped lessons in the five countries was rated by eighth-grade science teachers as "about the same" as most lessons (data not shown). The science content was described as "more difficult" in 3 to 10 percent of the lessons across the five countries, and as "less difficult" in 4 to 12 percent of the lessons.

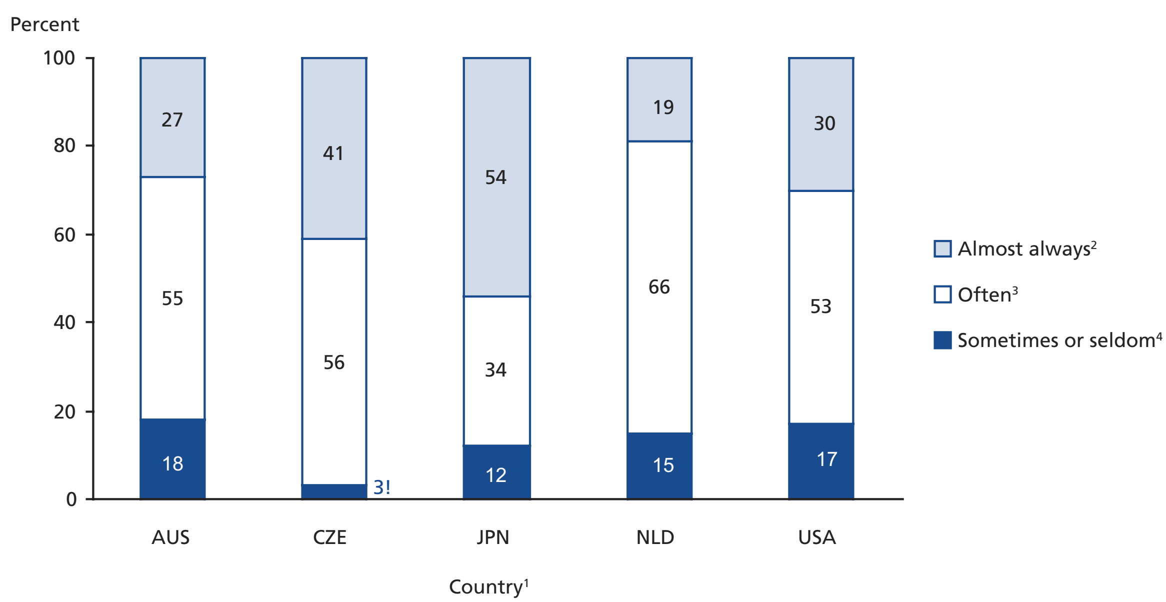
## Influence of Videotaping

- More eighth-grade science lessons in Australia (72 percent), Japan (60 percent), the Netherlands (87 percent), and the United States (90 percent) were taught by teachers who reported that the camera did not influence their teaching of the science lesson compared to Czech lessons (39 percent; data not shown). In the Czech Republic, teachers in 23 percent of the science lessons responded that the presence of the camera caused them to teach a lesson that was "better than usual" and in 37 percent of the lessons "worse than usual."

## Typicality of Planning for the Lesson

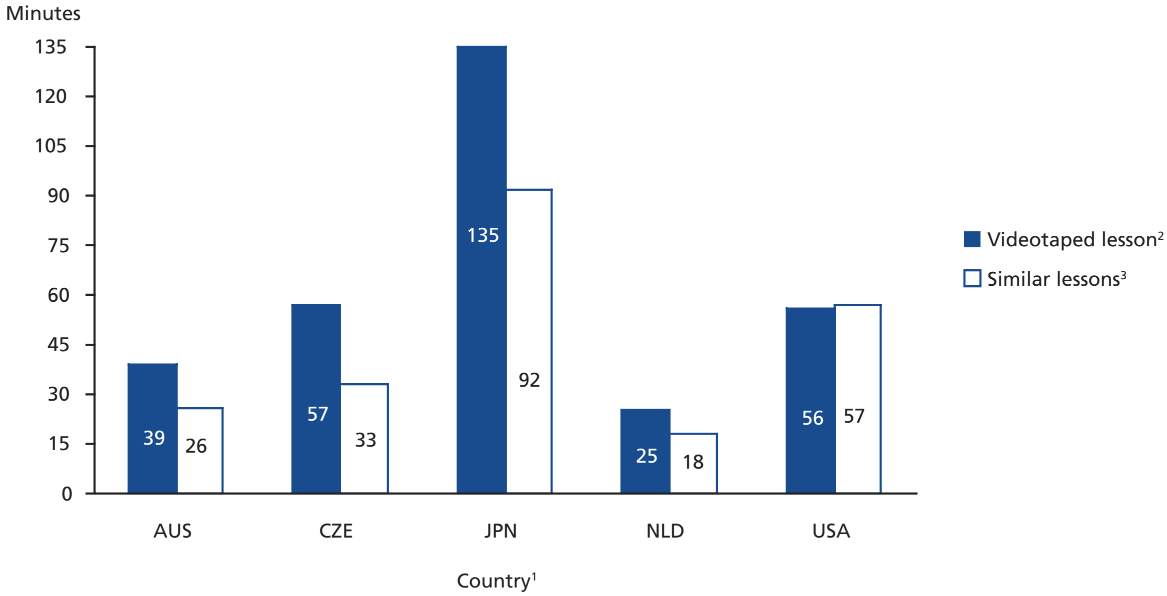
- Eighth-grade science lessons in Japan were taught by teachers who reported spending more time planning for the videotaped lesson (an average of 135 minutes) compared to teachers in the other four countries (25 to 57 minutes, on average; figure 2.5).
- Lessons within all the countries except the United States were taught by teachers who reported spending more planning time on videotaped lessons than on similar lessons (figure 2.5).

**FIGURE 2.4. Percentage distribution of eighth-grade science lessons taught by teachers who rated how often they used the teaching methods in the videotaped lesson, by country: 1999**




!Interpret data with caution. Estimate is unstable.
[1] AUS=Australia; CZE=Czech Republic; JPN=Japan; NLD=Netherlands; and USA=United States.
[2] Almost always: JPN>AUS, NLD, USA.
[3] Often: CZE, NLD>JPN.
[4] Sometimes or seldom: No measurable differences detected.
NOTE: Results based on science teachers' reports.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study, Video Study, 1999.

**FIGURE 2.5.** **Average length of time eighth-grade science teachers spent planning for the videotaped lesson and for similar science lessons, by country: 1999**




[1] AUS=Australia; CZE=Czech Republic; JPN=Japan; NLD=Netherlands; and USA=United States.
[2] Videotaped lesson: JPN>AUS, CZE, NLD, USA; CZE, USA>NLD.
[3] Similar lessons: CZE, JPN, USA>AUS, NLD; JPN, USA>CZE.
NOTE: Results based on science teachers' reports. Average length of time per country calculated as the sum of minutes reported for each lesson divided by the number of lessons within a country.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study, Video Study, 1999.

## Fit of the Lesson in the Curricular Sequence

A sequence of lessons is the usual structure teachers use to teach a particular topic in the curriculum. A lesson that is not identified as part of a sequence may indicate an atypical lesson conducted specifically for the benefit of this study. Teachers were asked to provide information on whether the videotaped lesson was part of a larger unit or sequence of related lessons, or whether it was a stand-alone lesson. If the videotaped eighth-grade science lesson was part of a unit or sequence, the teacher was asked to identify how many lessons were in the entire sequence and where the videotaped lesson fell in the sequence (e.g., lesson number 3 out of five lessons in the sequence).

- Between 96 and 99 percent of the eighth-grade science lessons in all the countries were taught by teachers who reported that the videotaped lesson was part of a sequence of lessons (data not shown). Table 2.8 shows that, on average, the total number of lessons in the larger sequence of which the videotaped lesson was a part ranged from 9 to 15 lessons across the participating countries. On average, the lessons captured on videotape were located mid-sequence in the lessons within the unit.

**TABLE 2.8. Average number of eighth-grade science lessons in unit or sequence and placement of the videotaped lesson in unit, by country: 1999**

| Country | Average number of lessons in unit[1] | Average placement of the videotaped lesson in unit[2] |
|---|---|---|
| Australia (AUS) | 15 | 8 |
| Czech Republic (CZE) | 9 | 4 |
| Japan (JPN) | 13 | 6 |
| Netherlands (NLD) | 11 | 6 |
| United States (USA) | 11 | 5 |

[1] Number of lessons: AUS>CZE, USA; JPN>CZE.
[2] Placement of the videotaped lesson in the unit: AUS>CZE, USA.
NOTE: Results based on science teachers' reports. Teachers were asked to provide information on whether the videotaped lesson was part of a larger unit or sequence of related lessons, or whether it was a stand-alone lesson. If the videotaped eighth-grade science lesson was part of a unit or sequence, the teacher was asked to identify how many lessons were in the entire sequence and where the videotaped lesson fell in the sequence.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study, Video Study, 1999.

## Summary

The findings from analyses of the teacher questionnaire responses provide a context within which to interpret those results presented in the following chapters on the nature of the videotaped lessons. Among the findings is that most eighth-grade science lessons in the five participating countries were taught by teachers who described the videotaped science lesson as typical of their teaching, even though more time than usual was spent planning for the videotaped lesson in four of the participating countries and more Czech teachers thought the videotaping influenced their students' behavior than teachers in three other countries. These results suggest that the lessons captured on videotape were relatively typical of the lessons that eighth-graders would experience in school in these five countries.

# 3 Chapter 3
## Instructional Organization of the Lessons

This chapter focuses on the ways teachers organize eighth-grade science lesson time. Examining how science lesson time is organized for different activity types and purposes lays the groundwork for understanding how science content ideas, processes, and structures are represented in the classroom (chapters 4-6) and the kinds of opportunities that students have to participate in learning science (chapters 7-11).

### Research Background

Analysis of the use of time as related to lesson organization provides an indication of the potential learning time for eighth-grade students, an issue the research literature suggests is an important predictor of academic learning (Denham and Lieberman 1980; Marzano 2000; National Commission on Excellence in Education 1983; Scheerens and Bosker 1997). The effective use of time is also one of the most consistent school factors related to student achievement (Hossler, Stage, and Gallagher 1988; Kane 1994; National Research Council (NRC) 1996). Maximizing the amount of instructional time, and especially the amount of time students are engaged in academic tasks, is correlated with higher student achievement (Denham and Lieberman 1980; Marzano 2000; Scheerens and Bosker 1997).

Investigations of the use of time in science lessons can reveal to what extent the lesson focused on science instruction, science organization issues, and non-science matters. Examination of how time is allocated within lessons can also reveal patterns of time usage for different purposes, for example, by focusing on development of new ideas, review of previous content, student assessment and homework.

At a gross level, how science teachers in each of the five participating countries organized lessons, and how much time was spent during the lessons on different purposes, sets the stage for much of the work that is accomplished in eighth-grade science. The organization of the lesson can enable or limit both the science content that is taught and the way that content is taught. For example, lessons that include time for practical, hands-on science activities and lessons that focus entirely on whole-class lecture and discussion provide students with different images of science and different science learning opportunities (Monk and Dillon 2000).

Chapter 3 focuses on four main questions about different organizational elements of eighth-grade science lessons:

- How much time was spent studying science and how was that time allocated during the lesson?
- How was the lesson organized for different instructional purposes?
- How was the lesson organized for practical and seatwork activities?
- How was the lesson organized for whole-class and independent work?

Together, these elements of lesson organization can contribute to the shape of science learning opportunities available to eighth-grade students. The analyses of the video data presented in this report are not meant to portray which country creates the "right" environment for eighth-grade students. Rather, the comparisons of science teaching provide educators an opportunity to examine the choices made about the organization of the lessons and, as we will see later in the report, about how science is presented and represented to students.

## How Much Time Was Spent Studying Science?

### Lesson Length

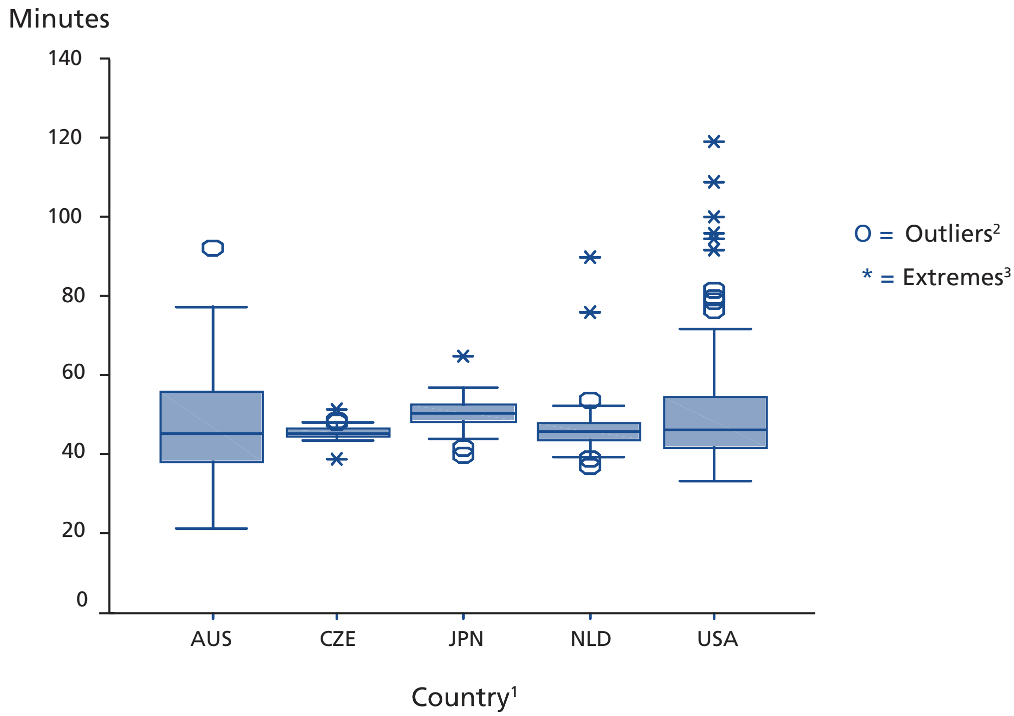
- Although the eighth-grade science lessons had a mean length between 46 and 51 minutes across the countries, a wide range of lesson lengths was found in some countries (table 3.1). The median length is a better measure for gauging the length of a typical lesson. In four of the five countries, the median length of an eighth-grade science lesson was 45 to 46 minutes. In Japan, the median length was 51 minutes.
- Figure 3.1 graphically provides a more detailed look at the variation in lesson length, indicating the lessons that were extremes or outliers in terms of duration. In the Czech Republic, Japan, and the Netherlands, lesson length for the middle 50 percent of lessons varied by no more than 4 minutes. The middle 50 percent of U.S. lessons varied in length by up to 12 minutes and Australian lessons by 17 minutes. This pattern was found even when outliers and extremes were excluded from the analysis (see whiskers on figure 3.1).

**TABLE 3.1. Mean, median, range, and standard deviation (in minutes) of the duration of eighth-grade science lessons, by country: 1999**

| Country | Mean[1] | Median | Range | Standard deviation[2] |
|---|---|---|---|---|
| Australia (AUS) | 49 | 45 | 21–92 | 14 |
| Czech Republic (CZE) | 46 | 45 | 39–52 | 1 |
| Japan (JPN) | 50 | 51 | 40–65 | 4 |
| Netherlands (NLD) | 47 | 46 | 37–90 | 8 |
| United States (USA) | 51 | 46 | 33–119 | 16 |

[1]Mean: JPN, USA>CZE; JPN>NLD.
[2]Standard deviation: AUS, JPN, NLD, USA>CZE; USA>JPN, NLD; AUS>JPN.
NOTE: Mean was calculated as the sum of the number of minutes of each lesson divided by the number of lessons within a country. For each country, median was determined by identifying the number of minutes in the lesson below which 50 percent of all lessons fell. Range describes the lowest number of minutes and the highest number of minutes observed within a country. The tests for significance take into account the standard error for the reported differences. Thus, a difference between averages of two countries may be significant while the same difference between two other countries may not be significant.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study (TIMSS), Video Study, 1999.

**FIGURE 3.1. Box and whisker plot showing the distribution of eighth-grade science lesson durations, by country: 1999**




[1] AUS=Australia; CZE=Czech Republic; JPN=Japan; NLD=Netherlands; and USA=United States.
[2] Outliers (values are 1.5 to 3.0 box lengths from upper or lower edge of box).
[3] Extremes (values greater than 3.0 box lengths from the upper or lower edge of the box).
NOTE: The shaded box represents the interquartile range, containing 50 percent of the lessons. The lines extending from the box indicate the highest and lowest values, excluding outliers and extremes. The horizontal line within the box indicates the median lesson time (half of the numbers fall above or below this value).
SOURCE: U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study (TIMSS), Video Study, 1999.

## Science Instruction, Science Organization, and Non-Science

Not every moment between the beginning and the end of a lesson is spent on events and activities directly related to eighth-grade science. For example, there are times during the lesson when the teacher carries out administrative tasks, disciplines students, or organizes physical arrangements for the students to conduct a laboratory experiment. To measure the amount of time during which the students had an opportunity to learn science, the following four categories were defined to segment the lesson.

- ***Science instruction:*** Time in the lesson when the teacher and at least one student engage in activities that provide opportunities for students to learn science. Examples of such activities include the teacher explaining science concepts, the class conducting and discussing experiments, and the students working on written assignments.
- ***Science organization:*** Time in the lesson that the teacher sets aside for organizational activities and discussions that are related to science study. Organizational activities include distributing or gathering papers or science materials, putting away or cleaning up science materials, talking about test grades or due dates without mentioning any science content, and students rearranging

themselves to watch a science demonstration. These activities and discussions usually are connected to the preparation, follow-up, or completion of science instruction activities. No explicit science instruction is conducted during this time, and students do not have any obvious opportunity to work on a science assignment.

- ***Non-science:*** Time in the lesson when no science-related activities or discussions take place and, therefore, students have no obvious opportunity to learn science. Non-science activities include the teacher taking attendance, announcing school events, disciplining students, and interruptions by outside sources such as a visitor.
- ***Technical difficulty:*** Time in the lesson when a technical problem with the video occurs which prevents accurate categorizing.

Table 3.2 presents the length of science instruction time in minutes and Figure 3.2 illustrates the average percentage of lesson time spent on science instruction, science organization, and non-science.

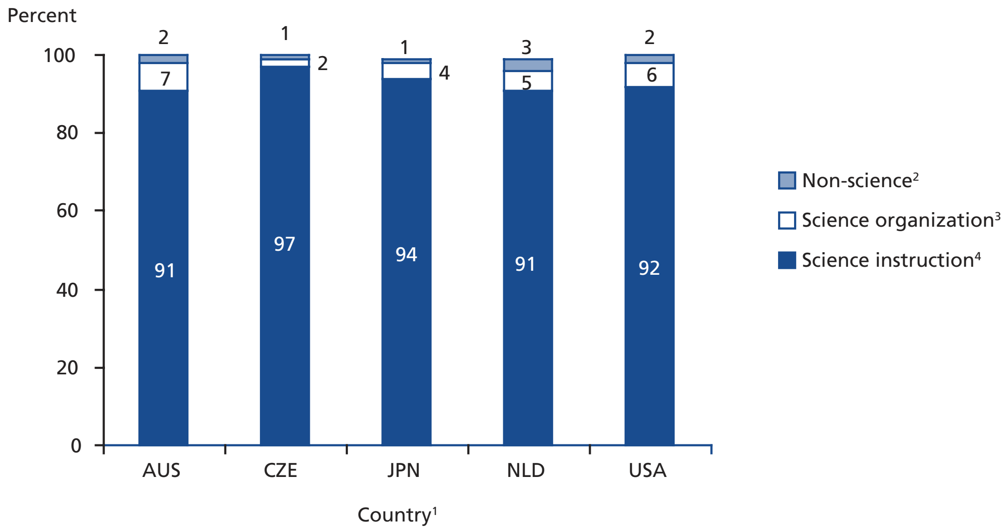
- Between 43 and 48 minutes, on average, were devoted to science instruction across countries, with median durations ranging from 42 to 48 minutes (table 3.2). Japanese lessons devoted more average time to science instruction than Czech and Dutch lessons.
- Czech and Japanese science lessons maximized time focused on science instruction. Eighth-grade science lessons in the Czech Republic allocated more time for science instruction and less time for science organizational activities than the other four countries (figure 3.2). Japanese science lessons included more time for science instruction than Australian and Dutch science lessons.
- Eighth-grade science teachers and students within each of the five countries spent a higher percentage of lesson time engaged in science instructional work than in non-science work or science organization (figure 3.2).
- More science organization time may be expected in eighth-grade lessons where students carried out experiments or other practical activities. When science organization time was compared in lessons in which students carried out independent practical activities and in lessons in which students carried out independent seatwork activities,[6] the average percentage of science organization time was not measurably different within Japan and within the Netherlands (data not shown). In Australia, however, a larger average proportion of time was allotted for science organization in those lessons that involved students in doing hands-on practical work independently. Conversely, within the Czech Republic and the United States, a smaller proportion of time was allotted for science organization in lessons that involved students in doing hands-on practical work independently.

**TABLE 3.2. Mean, median, range, and standard deviation (in minutes) of actual science instruction time of eighth-grade science lessons, by country: 1999**

| Country | Mean[1] | Median | Range | Standard deviation[2] |
|---|---|---|---|---|
| Australia (AUS) | 44 | 42 | 16-89 | 13 |
| Czech Republic (CZE) | 44 | 44 | 39-51 | 2 |
| Japan (JPN) | 48 | 48 | 38-59 | 4 |
| Netherlands (NLD) | 43 | 42 | 32-84 | 7 |
| United States (USA) | 47 | 43 | 30-119 | 15 |

[1]Mean: JPN>CZE, NLD.
[2]Standard deviation: AUS, JPN, NLD, USA>CZE; AUS, USA>JPN; USA>NLD.
NOTE: Mean was calculated as the sum of the number of minutes spent on science instruction of each lesson divided by the number of lessons within a country. For each country, median was determined by identifying the number of minutes in the lesson below which 50 percent of all lessons fell. Range describes the lowest number of minutes and the highest number of minutes observed within a country. The tests for significance take into account the standard error for the reported differences. Thus, a difference between averages of two countries may be significant while the same difference between two other countries may not be significant.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study (TIMSS), Video Study, 1999.

**FIGURE 3.2. Average percentage of eighth-grade science lesson time devoted to non-science, science organization, and science instruction, by country: 1999**




[1]AUS=Australia; CZE=Czech Republic; JPN=Japan; NLD=Netherlands; and USA=United States.
[2]Non-science: NLD>CZE, JPN.
[3]Science organization: AUS, JPN, NLD, USA>CZE; AUS>JPN.
Science organization and non-science: AUS, JPN, NLD, USA>CZE; AUS, NLD>JPN.
[4]Science instruction: CZE>AUS, JPN, NLD, USA; JPN>AUS, NLD.
NOTE: Total may not sum to 100 because of rounding and data not presented for the category technical difficulties. The tests for significance take into account the standard error for the reported differences. Thus, a difference between averages of two countries may be significant while the same difference between two other countries may not be significant.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study (TIMSS), Video Study, 1999.

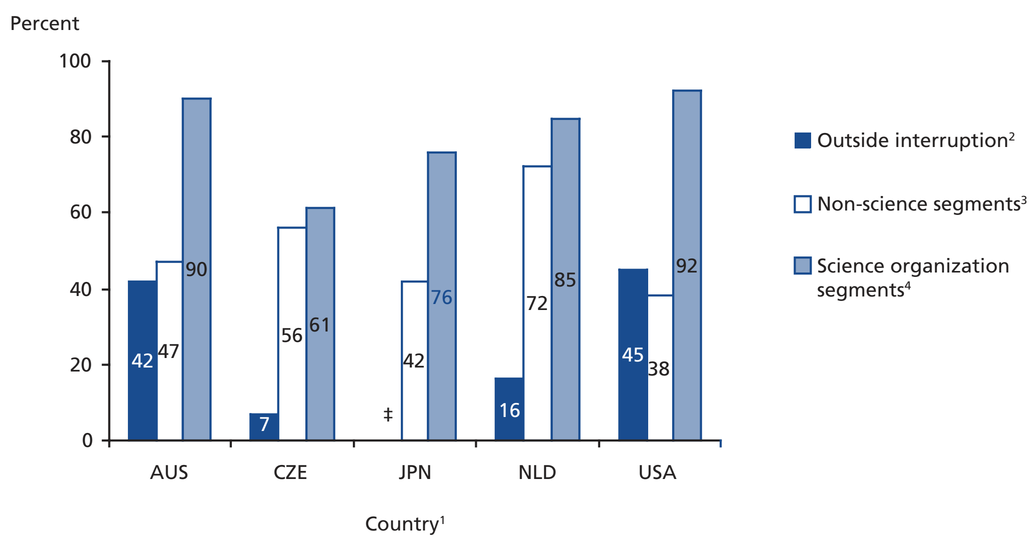
## Lesson Interruptions

Interruptions by an outside source (e.g., telephone, intercom, or visitor), by non-science segments in the middle of the lesson, or by multiple science organization segments were examined. These types of interruptions to the lesson flow indicate how countries organize their lessons with a minimum of interruptions. See appendix D for definitions of interruptions and other constructs investigated in this study.

- Eighth-grade science lessons in the Czech Republic included fewer incidences of outside interruptions and science organization than Australian and U.S. lessons. Lessons in the Netherlands included fewer outside interruptions than Australian and U.S. lessons but more interruptions by non-science activities than Australian, Japanese, and U.S. lessons (figure 3.3).

A smaller percentage of science lessons in the Czech Republic and Japan experienced at least three or more interruptions (by outside sources, by non-science activities, and/or by science organizational activities) compared to science lessons in the other countries (figure 3.3).

**FIGURE 3.3. Percentage of eighth-grade science lessons with any instance of outside interruptions, non-science segments, and science organization segments, bycountry: 1999**




‡ Reporting standards not met. Too few cases to be reported.
[1]AUS=Australia; CZE=Czech Republic; JPN=Japan; NLD=Netherlands; and USA=United States.
[2]Outside interruptions: AUS, USA>CZE, NLD.
[3]Non-science segments: NLD>AUS, JPN, USA.
[4]Science organization segments: AUS, NLD, USA>CZE; USA>JPN.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study (TIMSS), Video Study, 1999.

## How Was the Lesson Organized for Different Instructional Purposes?

To capture various purposes of lesson parts, the following five categories were developed and defined:

- ***Developing new content:*** Period of time when the main instructional activity takes place The purpose of such activities is to present, develop, elaborate, or apply scientific concepts, ideas, and/or procedures.
- ***Reviewing previous content:*** Period of time during the lesson when the content presented to students in previous lessons is repeated or revisited. No new content information is provided during this time except for simple referencing ( Video clip example 3.1).
- ***Going over homework:*** Period of time during the lesson that the teacher sets aside to correct, check, or go over students' homework after they had worked on or completed the assignment at home ( Video clip example 3.2).
- ***Assessing student learning:*** Time period during the lesson that the teacher sets aside to formally assess and/or grade students' work individually, as a small group, or as a whole class, either orally or in writing, or to check and/or go over tests, quizzes or other assessments that were previously completed (in the videotaped lessons or in previous lessons) ( Video clip example 3.3).
- ***Other purposes:*** A period during the lesson that the teacher sets aside for other purposes such as assigning homework or completing administrative tasks.

Table 3.3 presents the percentage of science lessons that contained at least one segment of a given type of lesson purpose and table 3.4 indicates the percentage of lesson time spent on each lesson purpose. Figure 3.4 shows the percentage distribution of lessons that only developed new content compared to lessons that included both review and new content development.

- Almost all of the eighth-grade science lessons in each country gave at least some attention to the development of new science content (table 3.3).
- Countries emphasized different purposes in their eighth-grade science lessons. Compared to the Czech Republic, the Netherlands, and the United States, a larger proportion of time in Japanese science lessons was spent on the development of new content (table 3.4). In contrast, science lessons in the Czech Republic were found to devote more time to the review of previously introduced content and more time for assessing student learning than lessons in three of the other countries. The Netherlands devoted more time during science lessons to going over homework than in the other countries. When examining only those Dutch lessons containing time to go over homework, it was found that an average of 25 percent of lesson time was focused on going over homework (data not shown).
- At least 57 percent of science lessons in all the countries except the Czech Republic focused only on developing new content with no review of previous content (figure 3.4). Science instruction in more Czech lessons both developed new content and reviewed previous learning compared to the other four countries.

**TABLE 3.3. Percentage of eighth-grade science lessons that contained at least one segment of a given type of lesson purpose, by country: 1999**

| Purpose | Australia (AUS) | Czech Republic (CZE) | Japan (JPN) | Netherlands (NLD) | United States (USA) |
|---|---|---|---|---|---|
| Developing new content[1] | 97 | 99 | 100 | 99 | 96 |
| Reviewing previous content[2] | 41 | 84 | 33 | 8 | 42 |
| Going over homework[3] | 2 | 3! | ‡ | 45 | 17 |
| Assessing student learning[4] | ‡ | 50 | 5 | 18 | 14 |
| Other purposes[5] | 99 | 98 | 99 | 100 | 92 |

!Interpret data with caution. Estimate is unstable.
‡Reporting standards not met. Too few cases to be reported.
[1] Developing new content: No measurable differences detected.
[2] Reviewing previous content: CZE>AUS, JPN, NLD, USA; AUS, JPN, USA>NLD.
[3] Going over homework: NLD>AUS, CZE, USA; USA>AUS.
[4] Assessing student learning: CZE> JPN, NLD, USA; NLD>JPN.
[5] Other purposes: NLD>USA.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study (TIMSS), Video Study, 1999.

**TABLE 3.4. Average percentage distribution of eighth-grade lesson time devoted to each type of lesson purpose, by country: 1999**

| Purpose | Australia (AUS) | Czech Republic (CZE) | Japan (JPN) | Netherlands (NLD) | United States (USA) |
|---|---|---|---|---|---|
| Developing new content[1] | 85 | 67 | 93 | 78 | 79 |
| Reviewing previous content[2] | 8 | 19 | 3 | 1! | 8 |
| Going over homework[3] | # | 1! | ‡ | 12 | 3 |
| Assessing student learning[4] | ‡ | 9 | 1 | 2 | 3 |
| Other purposes[5] | 7 | 4 | 3 | 7 | 8 |

#Rounds to zero.
!Interpret data with caution. Estimate is unstable.
‡Reporting standards not met. Too few cases to be reported.
[1] Developing new content: AUS, JPN, USA>CZE; JPN>NLD, USA.
[2] Reviewing previous content: CZE>AUS, JPN, NLD, USA; USA>JPN, NLD.
[3] Going over homework: NLD>AUS, CZE, USA.
[4] Assessing student learning: CZE> JPN, NLD, USA; NLD>JPN.
[5] Other purposes: AUS, NLD, USA>CZE, JPN.
NOTE: Total may not sum to 100 because of rounding and data not reported. The tests for significance take into account the standard error for the reported differences. Thus, a difference between averages of two countries may be significant while the same difference between two other countries may not be significant.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study (TIMSS), Video Study, 1999.

## How Was the Lesson Organized for Practical and Seatwork Activities?

Science lessons may include practical activities in which the teacher and/or students carry out experiments and other kinds of "hands-on" activities in addition to "seatwork" activities such as teacher lectures, class discussions, reading, and writing. Many countries emphasize the importance of practical activities, whether they describe them as involving investigations, inquiry, replications, demonstrations, project- or problem-based studies, or experimental work (Beatty and Woolnough 1982; Jenkins 1999; Kerr 1964; NRC 1996; Swain, Monk, and Johnson 1998; Watson 2000; Watson and Prieto 1994).

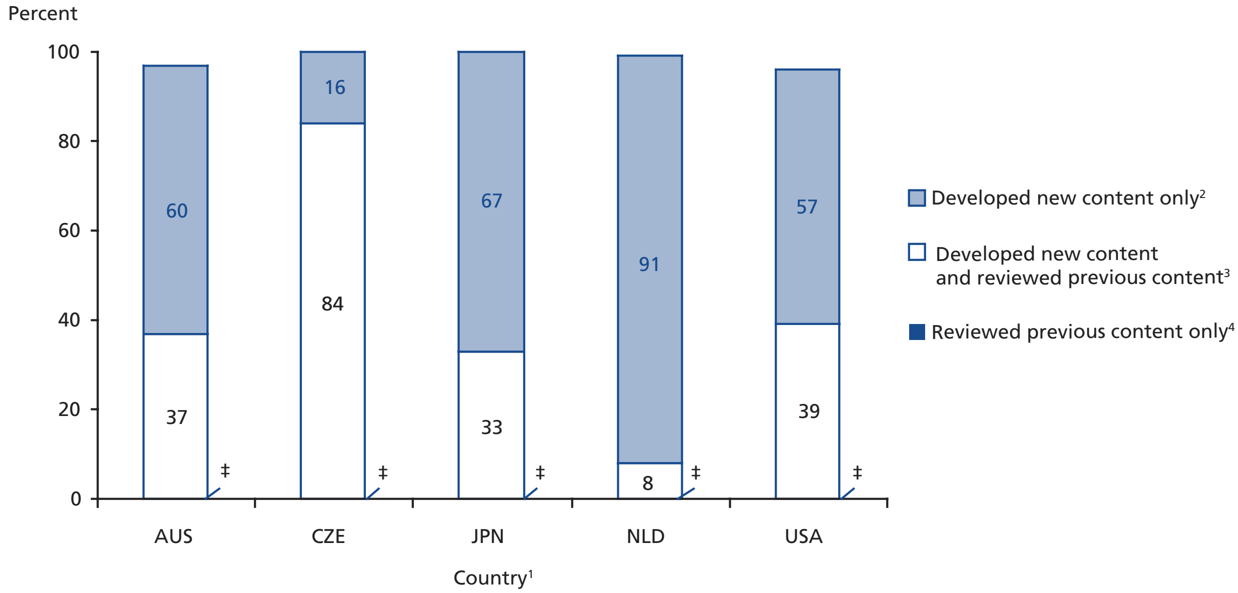
"Practical activities" is a term used in some countries to describe what may be referred to in other countries as "hands-on" or "laboratory" activities. The term "practical" is used in this report because it references or suggests a wider range of activities than may be suggested by the term "laboratory." In this study, practical activities were defined as those activities that provide students with the opportunity to observe and/or interact first-hand with objects and related phenomena. Practical activities include teacher demonstrations of phenomena and objects as well as student participation in traditional laboratory experiments and other hands-on interactions with objects such as producing and observing phenomena, building models, designing and testing technological solutions to problems, and observing objects.

In contrast, some studies point to stronger learning outcomes as a result of participation in seatwork activities compared to practical activities (Hodson 1993; Watson, Prieto, and Dillon 1995). "Seatwork activities" in this study refers to those activities seen in the videotaped science lessons that did not involve the use of objects. Seatwork activities include teacher lecture, class discussion, reading text, copying notes, small group discussions, and students' work on paper-and-pencil activities. The term "seatwork" should not be interpreted as meaning that students always stayed in their seats. For example, students might be out of their seats working on a large poster drawing on the floor. It should also be noted that students are often in their seats during practical activities; however, for the purposes of this study practical activities are not considered seatwork.

The percentage of lessons that contained practical and seatwork activities is presented below and the percentage of lesson time allocated to practical and seatwork activities is presented in figure 3.5.

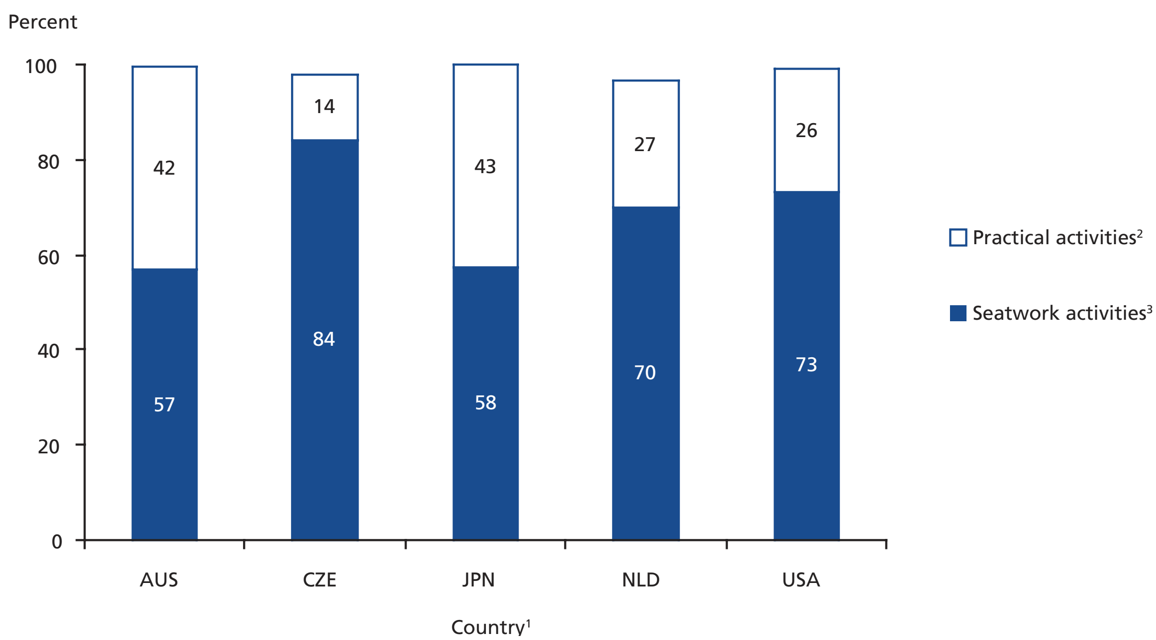
- Practical activities occurred in at least 72 percent of eighth-grade science lessons in each country, with more lessons containing practical activities in Australia (90 percent) than in the Netherlands (72 percent) (data not shown). Seatwork activities occurred in 100 percent of the science lessons in all the countries.
- Australian and Japanese lessons allocated larger percentages of science instruction time to practical activities than the other three countries, and smaller percentages of science instruction time to seatwork activities than the Czech Republic and the United States. Science lessons in the Czech Republic allocated a larger percentage of science instruction time to seatwork activities than the science lessons in the other countries with the exception of the United States.
- On average, all of the countries allocated a larger proportion of science instruction time to seatwork activities (57 to 84 percent) than to practical activities (14 to 43 percent; figure 3.5).

**FIGURE 3.4. Percentage distribution of eighth-grade science lessons that developed new content only, developed new content and reviewed previous content, and reviewed previous content only, by country: 1999**




‡Reporting standards not met. Too few cases to be reported.
[1] AUS=Australia; CZE=Czech Republic; JPN=Japan; NLD=Netherlands; and USA=United States.
[2] Developed new content only: AUS, JPN, NLD, USA>CZE; NLD>AUS, JPN, USA.
[3] Developed new content and reviewed previous content: CZE>AUS, JPN, NLD, USA; AUS, JPN, USA>NLD.
[4] Reviewed previous content only: No measurable differences detected.
NOTE: Total may not sum to 100 because of rounding and data not reported.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study (TIMSS), Video Study, 1999.

**FIGURE 3.5. Percentage distribution of science instruction time in eighth-grade science lessons devoted to practical activities and seatwork activities, by country: 1999**



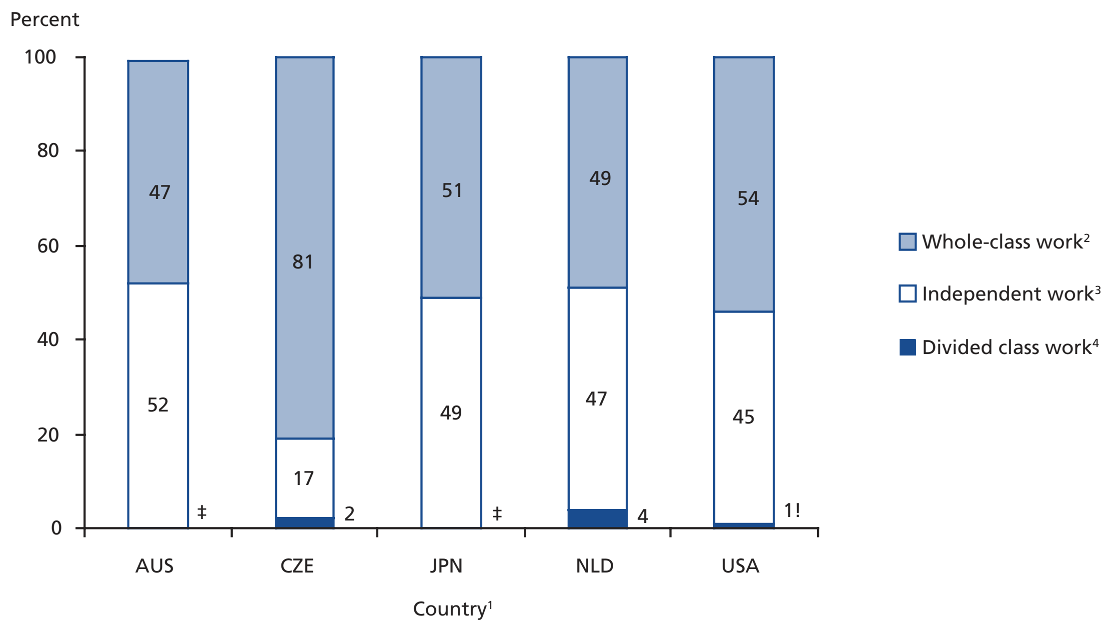

[1] AUS=Australia; CZE=Czech Republic; JPN=Japan; NLD=Netherlands; and USA=United States.
[2] Practical activities: AUS, JPN>CZE, NLD, USA; USA>CZE.
[3] Seatwork activities: CZE, USA>AUS, JPN; CZE>NLD.
NOTE: Total may not sum to 100 because of rounding and data not presented for 'divided class work' (see figure 3.6). Analysis is limited to those portions of lessons focused on science instruction. See table 3.2 and figure 3.2 for more details.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study (TIMSS), Video Study, 1999.

## How Was the Lesson Organized for Whole-Class and Independent Work?

Science activities were observed to take place as a whole class working together or as an independent activity where students worked either individually or in small groups. At times, science lessons were conducted in a divided class arrangement, where the teacher worked with part of the class while the rest of the class worked independently. See appendix D for more details on measures investigated in this study.

- The vast majority of eighth-grade science lessons contained at least some independent work (ranging from 92 percent of lessons in the Czech Republic to 100 percent in Australia) and at least some whole-class work (ranging from 98 percent in the Netherlands to 100 percent in the Czech Republic, Japan, and Australia; data not shown). Divided class work occurred in no more than 18 percent of the eighth-grade science lessons in all of the countries, accounting for no more than 4 percent of science instruction time in any of the countries (figure 3.6).
- Within all the participating countries except the Czech Republic, no measurable differences were found in the percentage of science instruction time that students worked as a whole-class or independently (figure 3.6). In the Czech science lessons, 81 percent of science instruction time was organized as a whole-class activity.

**FIGURE 3.6. Percentage distribution of science instruction time in eighth-grade science lessons devoted to whole-class work, independent work, and divided class work, by country: 1999**




!Interpret data with caution. Estimate is unstable.
‡Reporting standards not met. Too few cases to be reported.
1AUS=Australia; CZE=Czech Republic; JPN=Japan; NLD=Netherlands; and USA=United States.
2Whole-class work: CZE>AUS, JPN, NLD, USA.
3Independent work: AUS, JPN, NLD, USA>CZE.
4Divided class work: No measurable differences detected.
NOTE: Total may not sum to 100 because of rounding and data not reported. Analysis is limited to those portions of lessons focused on science instruction. See table 3.2 and figure 3.2 for more details.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study (TIMSS), Video Study, 1999.

## Practical and Seatwork Activities During Whole-Class and Independent Work

Practical and seatwork activities may occur in a whole-class setting or while students work independently. To explore further the nature of science activities across the countries, the relationship between practical and seatwork activities and the organization of the lesson in terms of whole-class or independent work was examined. The combination of activity and social organization types are described as follows:

- ***Independent practical activities:*** Hands-on work such as students conducting a laboratory experiment. Students are working either individually or in small groups on tasks that involve observing, handling, or manipulating objects, materials, 3-dimensional models, or organisms. Whole-class discussion time that precedes or follows the hands-on work is not included as part of the independent practical activity. (Video clip example 3.4)
- ***Independent seatwork activities:*** Students work individually or in small groups on student assignments, copying notes, and/or reading silently. Other examples of independent seatwork activities include answering questions in writing, writing an essay, drawing and/or labeling diagrams, completing worksheets, brainstorming ideas in a small group discussion, copying down or reading any written or drawn information presented on the blackboard, an overhead transparency, the textbook, or some other source. (Video clip examples 3.5 and 3.6)\
- Whole-class practical activities: Teacher demonstrations ranging from simple displays of science-related objects ("this is an ammeter" or "this is a model of a heart") to displays of objects with related phenomena (for example, using objects to show a chemical reaction) to public demonstration of complete experiments. These activities do not include discussion time that precedes or follows the observations. (Video clip examples 3.7 and 3.8)
- ***Whole-class seatwork activities:*** Oral lectures or discussions, often augmented by visuals. Examples of seatwork whole-class activities include the teacher presenting a new idea by showing and talking about a diagram, graph, map, or photograph or the teacher playing a videotape that presents both audio and visual information about the science content. (Video clip examples 3.9 and 3.10)

Practical activities occurred in at least 72 percent of the eighth-grade science lessons in the five countries (data not shown). The organization of the work and the amount of time allotted to it varied across the countries.

- Independent practical activities occurred in fewer Czech and Dutch science lessons than in Australian and Japanese science lessons. In the United States, fewer lessons than Australia and more lessons than the Czech Republic provided students with independent practical activities (table 3.5).
- Australian and Japanese science lessons allocated more time for independent practical activities than Czech and Dutch lessons. Four percent of instructional time was spent on independent practical activities in Czech science lessons, less than in the science lessons of the other countries (figure 3.7).
- Dutch science lessons allocated more time for independent seatwork activities than Czech and Japanese science lessons (figure 3.7).

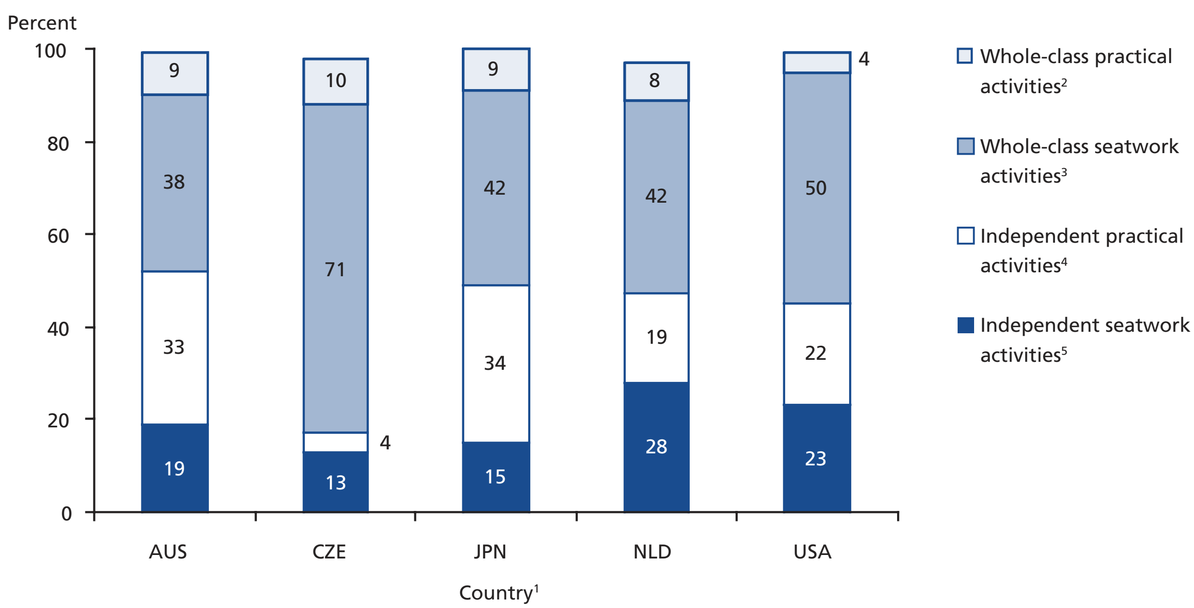
- In contrast with the other four countries, practical activities within Czech science lessons occurred more often as a whole-class activity than an independent activity (figure 3.7). (Video clip examples 3.7, 3.8, 3.9, and 3.10)

**TABLE 3.5.** **Percentage of eighth-grade science lessons that contained at least one segment of each combination of science activity and lesson organization type, by country: 1999**

| Lesson organization type | Activity type | Examples of activities | Country[1] AUS | CZE | JPN | NLD | USA |
|---|---|---|---|---|---|---|---|
| Whole-class | Practical[2] | Discussing and showing objects to whole class, demonstrations | 81 | 80 | 77 | 62 | 69 |
| | Seatwork[3] | Presentations, discussions | 100 | 100 | 100 | 98 | 99 |
| Independent | Practical[4] | Experiments, model building | 74 | 23 | 67 | 30 | 47 |
| | Seatwork[5] | Answering written questions, discussing in small groups, copying notes from blackboard, reading textbook | 88 | 88 | 81 | 77 | 86 |

[1] AUS=Australia; CZE=Czech Republic; JPN=Japan; NLD=Netherlands; and USA=United States.
[2] Whole-class practical activities: No measurable differences detected.
[3] Whole-class seatwork activities: No measurable differences detected.
[4] Independent practical activities: AUS, JPN>CZE, NLD; AUS>USA; USA>CZE.
[5] Independent seatwork activities: No measurable differences detected.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study (TIMSS), Video Study, 1999.

**FIGURE 3.7.** **Percentage distribution of science instruction time in eighth-grade science lessons devoted to each combination of science activity and social organization type, by country: 1999**




[1] AUS=Australia; CZE=Czech Republic; JPN=Japan; NLD=Netherlands; and USA=United States.
[2] Whole-class practical activities: AUS, CZE, JPN>USA.
[3] Whole-class seatwork activities: CZE>AUS, JPN, NLD, USA; USA>AUS.
[4] Independent practical activities: AUS, JPN, NLD, USA>CZE; AUS, JPN>NLD.
[5] Independent seatwork activities: NLD>CZE, JPN; USA>CZE.
NOTE: Total may not sum to 100 because of rounding and data not presented for "divided class work." Analysis is limited to those portions of lessons focused on science instruction. See table 3.2 and figure 3.2 for more details.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study (TIMSS), Video Study, 1999.

## Summary

In addition to setting the stage for examination of the science content of the lesson, the descriptions in this chapter also begin to address questions about how science was represented in the lesson and how students were involved in doing science work. The findings suggest differences among the countries in the time set aside for various purposes in science lessons, the kinds of activities that students work on, and whether these activities are carried out independently or in a whole-class setting. Czech and Japanese science lessons maximized lesson time spent on science instruction. Czech lessons devoted a larger percentage of time to reviewing previously introduced content than all the other countries, and allocated more time for assessing student learning than three of the other countries. Dutch lessons spent more time on going over homework than all of the other countries with reliable estimates. Students in Australian and Japanese classrooms worked independently on hands-on practical activities for a higher percentage of lesson time than students in the Czech Republic and the Netherlands. In contrast, students in Czech eighth-grade science lessons were engaged in whole-class activities for 81 percent of the lesson time, more than in all of the other countries.

# 4 Chapter 4: Science Content of the Lessons

This chapter describes the content of the eighth-grade science lessons according to disciplines (i.e., earth science, life science, physics, chemistry, and other areas), topics within those disciplines, and the types of science knowledge that were addressed in the lesson. Both the research literature and the standards and curriculum documents have different ways of thinking about content of the science curriculum.

## Research Background

The history of science education is characterized by debates about what science content should be learned in school science classes. Current debates in the field focus on the appropriate balance of different types of knowledge in the science curricula. Among the many issues raised during these debates are the degree to which curricula should focus on mastering facts, definitions, and concepts versus developing scientific inquiry abilities (Bybee 2000; Lehrer et al. 2000; Metzenberg 1998a; Schultz 1998; Strauss 2004); the degree to which societal and technological issues linked to real-world problems should form the basis of science curricula (Bybee 1987; Eijkelhof and Voogt 2001; Moje, Collazo, Carillo, and Marx 2001); and the degree to which curricula should focus on student understanding of major themes about the nature of science and big ideas that cut across the traditional disciplines or on specific knowledge of the traditional science disciplines (California Department of Education 2000; Metzenberg 1998a, 1998b; National Science Teachers Association 1992a, 1992b).

In some countries, science teaching has been characterized as emphasizing science as a body of canonical knowledge (i.e., the body of knowledge taken to be fact) (Bybee and DeBoer 1994; DeBoer 1991; Osborne 2000). This is based on qualitative and survey studies that portray science teaching and science textbooks in these countries as focusing on the facts, concepts, theories, and ideas that are produced by the scientific community and paying less attention to the nature and history of science, the connections between science and societal applications, and the importance of science to society (Bybee and DeBoer 1994; DeBoer 1991; Eichinger and Roth 1991; Helgeson, Blosser, and Howe 1977; Kesidou and Roseman 2002; Stake and Easley 1978; Weiss 1978). In other countries, observations of science teaching suggest more emphasis on knowledge about scientific inquiry processes, the connections between canonical knowledge and societal applications, and the nature of scientific knowledge (e.g., Andersson 2000; Australian Education Council 1994; Board of Studies 1995; DeVos and Reiding 1999; Goto 2001; Millar and Osborne 1998; Moller Anderson, Schnack, and Sorensen 1995; NRC 1996; OECD/PISA 1999).

Including societal and real-life issues in the content of school science curricula is supported in some countries as a strategy for clarifying and illustrating science concepts, capturing students' interests and helping students see the usefulness of science concepts. In support of this, research on student learning suggests the need for students to see the wide usefulness of an idea in a variety of real-world contexts before that idea will become meaningfully understood (Anderson and Roth 1989; Driver et al. 1994; Hewson, Beeth, and Thorley 1998; Posner et al. 1982). Results from studies of learning and motivation have led many researchers to emphasize the importance of "situated cognition" and authentic contexts to promote learning (Brown, Collins, and Duguid 1989; Edelson 1998; Moje et al. 2001; Roth 1995). Other researchers advocate using real-life issues to develop students' conceptual understandings; they put real-life issues at the center of the curriculum, emphasizing knowledge about the interactions of science, technology, and society as the primary content in science instruction (Bybee 1987; Krajcik et al. 1998).

Cognitive science research describes another type of knowledge that may be explicitly addressed in science lessons. Meta-cognitive knowledge refers to information about strategies for learning (learning how to learn) or the importance of reflecting on one's knowledge and learning as part of the learning process. Meta-cognitive knowledge includes monitoring one's own comprehension, evaluating progress toward completing a task, and reflecting on how thinking and understandings have changed over time. Empirical research in various school subject matter areas provides promising evidence that teaching students to reflect on their thinking processes promotes content learning (Anderson and Roth 1989; Bielaczyc, Pirolli, and Brown 1995; Borkowski and Muthukrishna 1992; Novak and Gowin 1984; Otero and Companario 1990; Palincsar and Brown 1984; Pressley and Levin 1983; Scardamalia, Bereiter, and Steinbach 1984; Schoenfeld 1988).

## Country Perspectives

Standards and curriculum documents from the countries in this study differ in the degree to which they emphasize different types of scientific knowledge.[7] The Czech Republic's national curriculum guidelines emphasize canonical knowledge (e.g., science facts, ideas, concepts or theories), communicating the science ideas that students are expected to learn about science (Kolavova 1998; Nelesovska and Spalcilova 1998). Documents in Australia, Japan, the Netherlands, and the United States suggest an approach which, in addition to canonical knowledge, also puts considerable emphasis on knowledge about scientific processes and real-life issues (Australian Education Council 1994; Board of Studies 1995; NRC 1996; Dutch Ministry of Education, Culture, and Science 1998; Ministry of Education, Science, and Culture [*Monbusho*] 1999). For instance, the Dutch document on science educational objectives highlights goals related to societal issues—for example, applications of biology in students' personal lives (consumer behavior, health, sexuality, and the environment), recognition and valuing biological aspects of social situations, and use of biological knowledge and skills to facilitate personal decisions (about education, employment, and social activity) (Dutch Ministry of Education, Culture, and Science 1998). Tenth-grade students are required to take an entire course that focuses on public issues in science education (DeVos and Reiding 1999). Current reform movements in Japan also call for increased emphasis on connecting science to real-life issues to make science more meaningful and interesting for students (Goto 2001). Earlier TIMSS

[7] As stated in the introduction to this report, of the five participating countries, three (the Czech Republic, Japan, and the Netherlands) have national curricula and guidelines. Australia and the United States do not have national curricula, standards, or guidelines; rather, decisions regarding curricula are taken at the state, provincial, or local level. Therefore, in the case of Australia and the United States, references to standards, curricular guidelines, and reform documents should not be construed as official or definitive statements of national, state, provincial, or local governments. Rather, the documents cited for these two countries represent the most widely referenced and distributed curricular and standards documents available at the time the study was conducted.

1999 findings indicated low percentages of Japanese students who report an interest in science or see science as important to their daily lives (Beaton et al. 1996; Goto 2001). The Czech Republic's curriculum guidelines, on the other hand, only briefly mention real-life issues (Czech Ministry of Education 1996). Public talk about issues such as the values and dispositions of science (e.g., open-mindedness, skepticism, and objectivity) and the nature of scientific knowledge (e.g., evidence-based or tentative) is one strategy for providing students with opportunities to learn about what it means to do science.

Australian and U.S. documents also emphasize understanding the nature of science, which includes understanding its history as an ongoing and changing enterprise, understanding the scientific values and habits of mind that underlie the doing of science, and understanding the role that science has played in the development of various cultures (Australian Education Council 1994; NRC 1996). Knowledge about the nature of science knowledge is not explicitly represented in curriculum documents in the other countries.

Knowledge about safety is specifically mentioned in standards and curriculum documents in each of the countries. For example, one of the general attainment targets in the Netherlands for science is "using materials, tools, and equipment safely and efficiently" (Dutch Ministry of Education, Culture, and Science 1998, p. 11). In the *National Science Education Standards* (NRC 1996) in the United States, safety is referenced within the content standard of "Design and Conduct of Scientific Investigations."

## Defining Science Content

Science content is defined in this report using the broadest definition found in any of the country standards or curriculum documents. According to the *National Science Education Standards* distributed in the United States: "The content of school science is broadly defined to include specific capacities, understandings, and abilities in science" (NRC 1996, p. 22). Thus, science content includes

- understandings about the facts, definitions, terms, concepts, and processes that constitute canonical science knowledge (e.g., names of the organs in the excretory system, the idea that plants make their own food in the form of glucose, how the particulate theory of matter explains the water cycle);
- understandings about the nature of science and technology (e.g., how scientists use evidence to support claims, science as a human endeavor, scientific values, how science works, and history of science and technology);
- understandings about science in relationship to personal and societal issues (e.g., personal health, environmental issues, natural hazards, risks and benefits, and the impact of science and technology on society); and
- skills to carry out science and technology procedures (e.g., how to use tools such as balances or microscopes, and how to use experimental methods such as litmus tests or density calculations).

Chapter 4 focuses on two main questions about the nature of the science content of the eighth-grade science lessons in the five countries:

- Which science disciplines and topics are addressed in the lessons?
- What types of science knowledge are addressed in the lessons?

## Which Science Disciplines and Topics Are Addressed in the Lessons?

The science topics in the lessons were identified using the TIMSS *Guidebook to Examine School Curricula* (McNeely 1997), which provided a common, international frame of reference for talking about science content. Although the guidebook identified frameworks for curriculum analysis other than science disciplines and topics (i.e., performance expectations and perspectives), analysis for this video study focused only on the science content disciplines and topics.

The content of each lesson was described at two levels: a content discipline category and a content topic subcategory. The major science disciplines include: earth science, life science, physics, chemistry, and other.[8] Eighth-grade students in the Czech Republic and the Netherlands are taught some of these science disciplines in separate courses (biology, chemistry, and physics), while in Australia, Japan, and the United States science is taught as integrated science disciplines or general science. An "other" category was used to describe disciplinary areas in science that were taught in only small percentages of eighth-grade science lessons. These include: science, technology, and mathematics; history of science and technology; environmental and resource issues related to science; nature of science; and science and other disciplines.

The content subcategories specify topics at the level typically used by the classroom teachers in describing the content of the lesson on the questionnaires (e.g., rocks and soil, organs and tissues, electricity, and chemical changes). Although multiple science topics may be included in one science lesson, only the primary science topic for each lesson was identified. The primary topic was defined as the topic that was addressed for the longest amount of science instruction time.

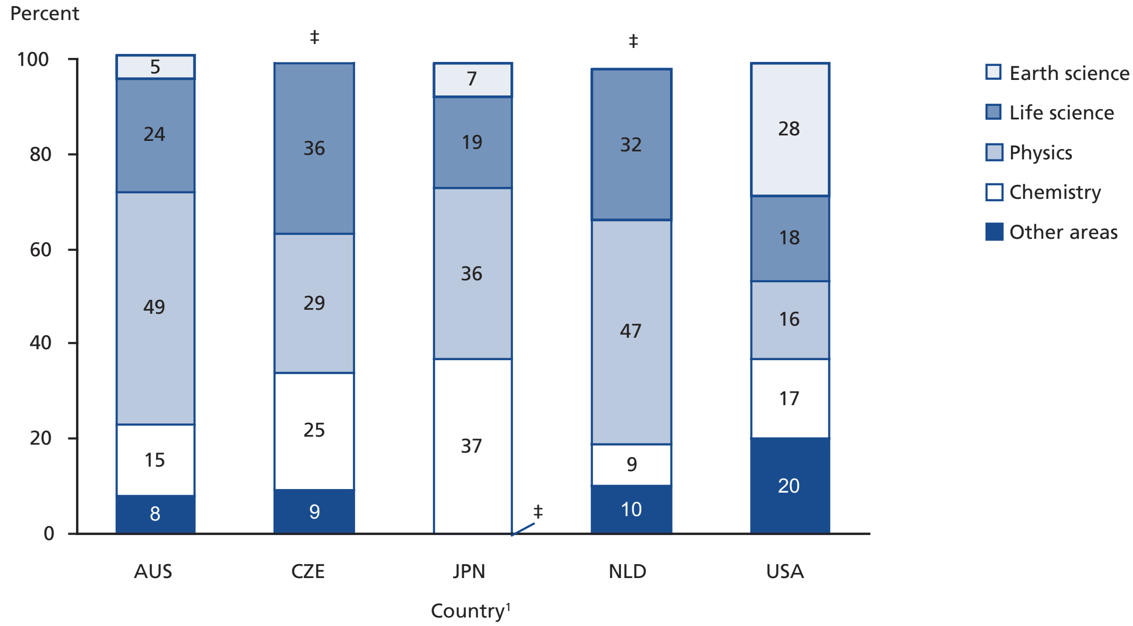
No statistical comparisons are made for curricular differences across countries because the video lessons were not sampled for specific disciplines or content. Therefore, discussion of the content disciplines covered in the videotaped lessons is limited to description of within-country content coverage only.

### Content Disciplines

- At least 47 percent of Australian and Dutch eighth-grade science lessons addressed physics topics; 36 percent of Czech lessons addressed life science topics; 37 percent of Japanese lessons addressed chemistry and 36 percent addressed physics; and 28 percent of U.S. lessons addressed earth science (figure 4.1). Earth science appeared in 5 percent of Australian lessons and 7 percent of Japanese lessons.
- Except within the United States, the content disciplines observed within all of the other countries were not evenly distributed across the science lessons (figure 4.1). Within the United States, no measurable differences were found for any comparison between science content disciplines.

[8] Since physical science is taught as separate courses for physics and chemistry in two of the five participating countries (the Czech Republic and the Netherlands), the original content category from the TIMSS Guidebook to Examine School Curricula (McNeely 1997) was modified in this study to identify physics and chemistry as separate content disciplines.

**Figure 4.1.** **Percentage distribution of eighth-grade science lessons devoted to life science, earth science, physics, chemistry, and other areas, by country: 1999**




‡Reporting standards not met. Too few cases to be reported.
[1] AUS=Australia; CZE=Czech Republic; JPN=Japan; NLD=Netherlands; and USA=United States.
NOTE: Total may not sum to 100 because of rounding. Other areas include: interactions of science, technology, and society; nature of scientific knowledge; and science and mathematics.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study (TIMSS), Video Study, 1999.

Within Australia and Japan, more lessons addressed life sciences, physics, and chemistry than earth sciences, and physics than life sciences. More Australian lessons addressed physics than chemistry whereas more Japanese lessons addressed chemistry than life sciences. Within the Netherlands, more lessons addressed life science and physics than chemistry.

- The definition of earth science varied across the countries. Earth science was addressed in too few eighth-grade science lessons in the Czech Republic and the Netherlands to calculate reliable estimates. This fact could point to differing views of what qualifies as science and what qualifies as earth science. Educators in the Czech Republic and the Netherlands do not regard geology, meteorology, and other subject areas constituting earth science as a separate science (Dutch Ministry of Education, Culture, and Science 1998; Kolavova 1998; Nelesovska and Spalcilova 1998). Instead, these earth science topics are often included as part of physics or, more commonly, as geography which is considered a social science in other countries and, therefore, not sampled in this study.

## Content Topics

There were commonly taught topics in life and physical science areas:

- In life science, a commonly taught topic in the eighth-grade was organs and tissues which was the focus of 19 percent of Czech lessons, 13 percent of Japanese lessons, 16 percent of Dutch lessons, and 5 percent of Australian lessons. Organs and tissues was not a topic taught in any of the U.S. lessons.

- In physics, electricity was taught in all five countries, ranging from 3 percent of lessons in the Netherlands and the United States to 28 percent of the lessons in Japan. In Japan, two topics—chemical changes and electricity—accounted for 61 percent of the science lessons.
- Fourteen different topics were identified within the U.S. science lessons, and none accounted for more than 7 percent of the lessons. In comparison, Japanese lessons addressed seven different topics, with 33 percent of the lessons covering chemical changes, 28 percent targeting electricity, and 13 percent covering organs and tissues.

Tables E.1–E.5 in appendix E provide more specific information on the topics taught in the science lessons from the five countries.

## What Types of Science Knowledge Are Addressed in the Lessons?

During a science lesson many different types of science knowledge can be addressed. To identify and measure the amount of time during which the students had an opportunity to learn about different types of knowledge, the eighth-grade science lessons were segmented into the following six types of science knowledge.

- ***Canonical knowledge:*** Time in the lesson when the teacher or students publicly talk about or examine information about scientific facts, concepts, ideas, processes, or theories. Canonical knowledge is the "what" and "why" of science, or the knowledge that science produces. This type of propositional knowledge is commonly found in science textbooks. (📹 Video clip example 4.1) Canonical knowledge can usually be characterized as one or more of the following types:
    - scientific conventions, labels, or identifications;
    - science concepts, or processes;
    - science-related patterns, trends, or laws; or
    - science-related explanations, theories, models, or interpretations.

Examples include: names of different bones, the process of photosynthesis, global warming patterns, explanations for season changes, evolutionary theory, and atomic models.

- ***Real-life issues:*** Time in the lesson when the teacher and students publicly talk about or examine information about how science knowledge is used, applied, or related to societal issues or to students' personal lives. This type of knowledge includes any talk about real-life issues that is topically related to the content of the science lesson, but it may or may not be closely linked to the development of content ideas. (📹 Video clip example 4.2) This type of knowledge includes:
    - talk about the relationship of personal experiences to science issues and ideas;
    - the uses of science knowledge in everyday life;
    - practical or motivational reasons to learn about science; or
    - everyday examples or illustrations of scientific ideas.

For example, the teacher may lead a discussion about what it is like to ride a bike on the pavement as opposed to a gravel road to support an idea about friction.

- ***Procedural and experimental knowledge:*** Time in the lesson when the teacher or students publicly talk about or examine together information about how to do science-related practices such as manipulating materials and performing experimental processes. While canonical knowledge can be thought of as the products of scientific inquiry, procedural and experimental knowledge can be thought of as the knowledge used to arrive at these products. (Video clip example 4.3) The most common example of this kind of knowledge involves how to manipulate materials or perform experimental procedures (e.g., how to connect a circuit, how to use litmus paper to tell if a substance is an acid or a base). However, also included are teachers' directions about how to manipulate formulas (e.g., how to balance a chemical equation), and how to carry out scientific thinking practices in the lesson (e.g., "When you do this experiment, be sure to think about what evidence you are gathering that either supports or challenges your hypothesis").
- ***Classroom safety knowledge:*** Time in the lesson when the teacher or students publicly talk about science-related safety issues in the classroom environment. Examples of this type of knowledge include identifying dangerous materials and discussing how to handle materials safely (e.g., what to do if hydrochloric acid spills). (Video clip example 4.4)
- ***Nature of science knowledge:*** Time in the lesson when the teacher or students publicly and explicitly refer to issues about how science is conducted. Nature of science knowledge includes values of science and science dispositions (e.g., open-mindedness, skepticism, and objectivity), scientific methods, the scientific enterprise, how scientists work and communicate, the sociology of science, ethics in science, politics of science, and philosophy of science. For example, the teacher states: "In science, you must always support your explanations with evidence, and certain kinds of evidence are more persuasive than others." This would be considered nature of science because it makes explicit a view of science in general that goes beyond the particular activity or content being discussed. (Video clip examples 4.5 and 4.6)
- ***Meta-cognitive knowledge:*** Time in the lesson when the teacher or students publicly discuss or present information about strategies for learning (learning how to learn) or the importance of reflecting on one's knowledge and learning as part of the learning process. Examples of this type of knowledge include the teacher modeling thinking (e.g., the teacher shows students how to work through a difficult problem or students reflect on how or why their thinking has changed). (Video clip example 4.7)

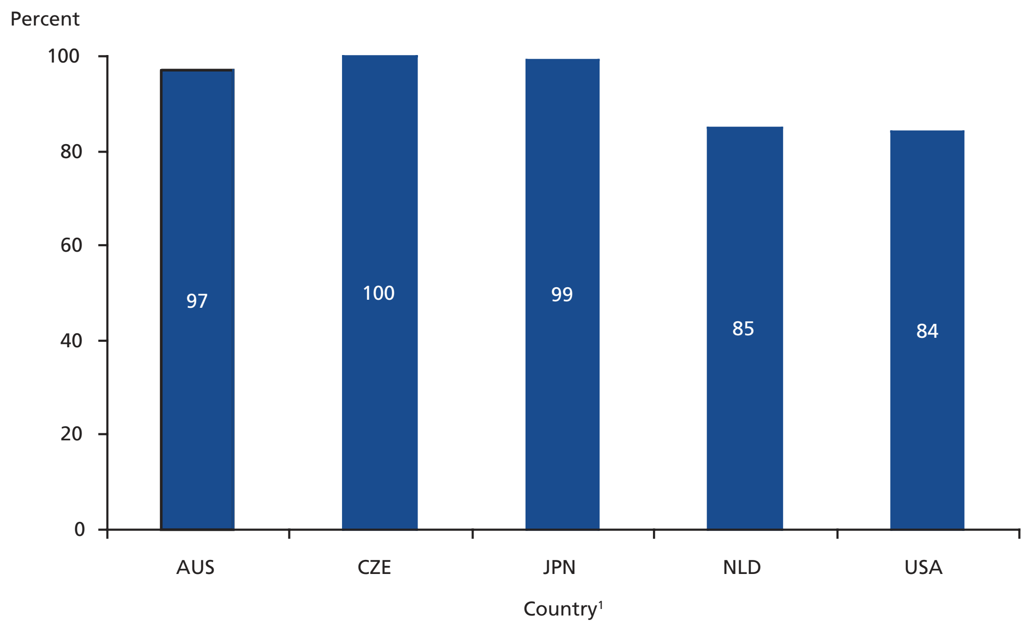
The above categories were applied to all the lessons but restricted to those sections of the lesson when the intended audience of the speaker (the teacher or a student) was the whole class. These sections of the lesson are identified as public talk segments. Public talk segments usually occurred during whole-class interactions, but there were occasions when the teacher spoke briefly to the whole class while they were working on an independent activity. Public talk during an independent activity was included in these analyses.[9] The above categories were not applied to non-public segments of the lesson because of the nature of independent work and the limits of the video methodology. During independent work, students were typically working independently on a set of tasks that may involve different types of knowledge occurring for different students at different points in time.

[9] For more details on public talk, see chapter 9.

## Canonical Knowledge

- Across all five participating countries, 84 percent or more of the eighth-grade science lessons publicly addressed canonical knowledge (figure 4.2). Lessons in the Czech Republic devoted a larger proportion of public talk time, on average, to addressing canonical knowledge (59 percent) than lessons in the other countries (figure 4.3).

**FIGURE 4.2.** **Percentage of eighth-grade science lessons that addressed canonical knowledge during public talk, by country: 1999**

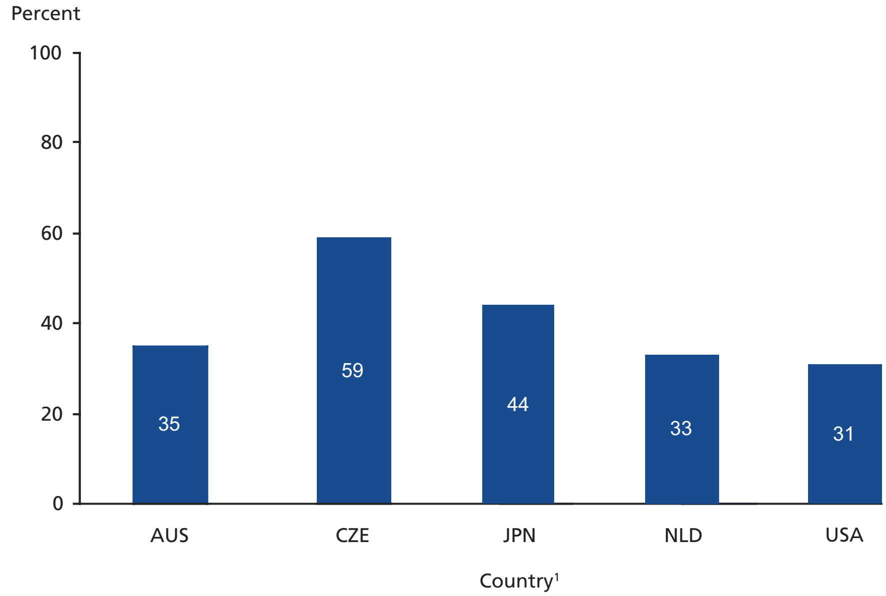



[1] AUS=Australia; CZE=Czech Republic; JPN=Japan; NLD=Netherlands; and USA=United States.
NOTE: CZE>NLD, USA; JPN>NLD. The above category was not applied to non-public segments of the lesson because of the nature of independent work and the limitations of the video methodology. During non-public talk segments, students were typically working independently on a set of tasks that may involve different types of knowledge.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study (TIMSS), Video Study, 1999.

## Real-Life Issues

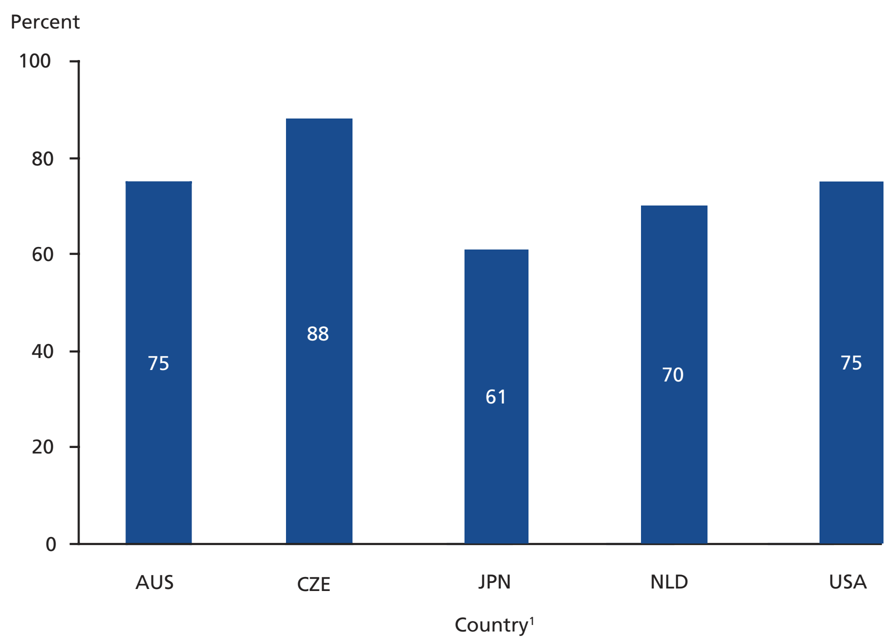
- Knowledge about real-life issues was publicly developed in at least 61 percent of the eighth-grade science lessons in all of the countries (figure 4.4). Japanese lessons allocated less public talk time to real-life issues than Czech, Dutch, and U.S. lessons (figure 4.5).

**FIGURE 4.3. Average percentage of public talk time in eighth-grade science lessons** devoted to canonical knowledge, by country: 1999



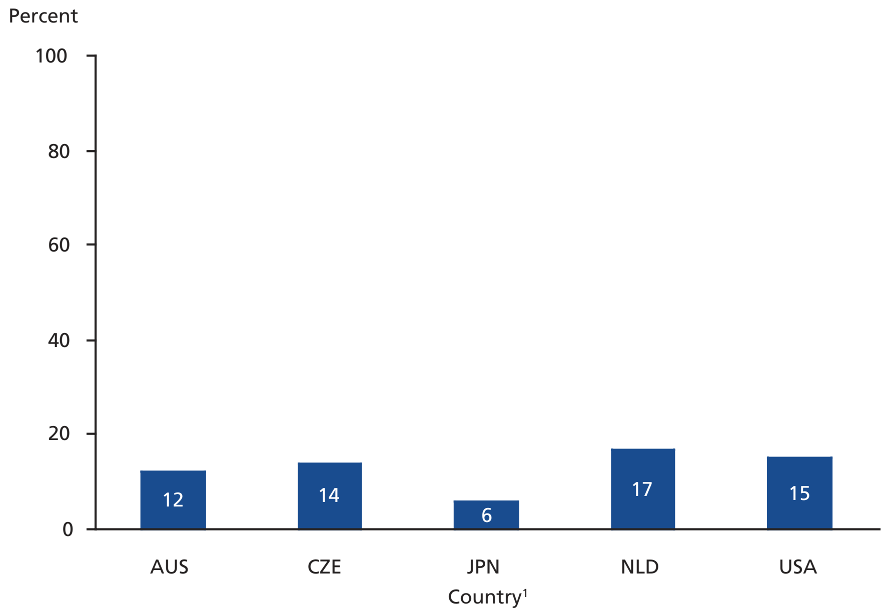

[1] AUS=Australia; CZE=Czech Republic; JPN=Japan; NLD=Netherlands; and USA=United States.
NOTE: CZE>AUS, JPN, NLD, USA; JPN>USA. Analysis is limited to public talk time. The above category was not applied to non-public segments of the lesson because of the nature of independent work and the limitations of the video methodology. During non-public talk segments, students were typically working independently on a set of tasks that may involve different types of knowledge.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study (TIMSS), Video Study, 1999.

**FIGURE 4.4. Percentage of eighth-grade science lessons that incorporated real-life issues during public talk, by country: 1999**



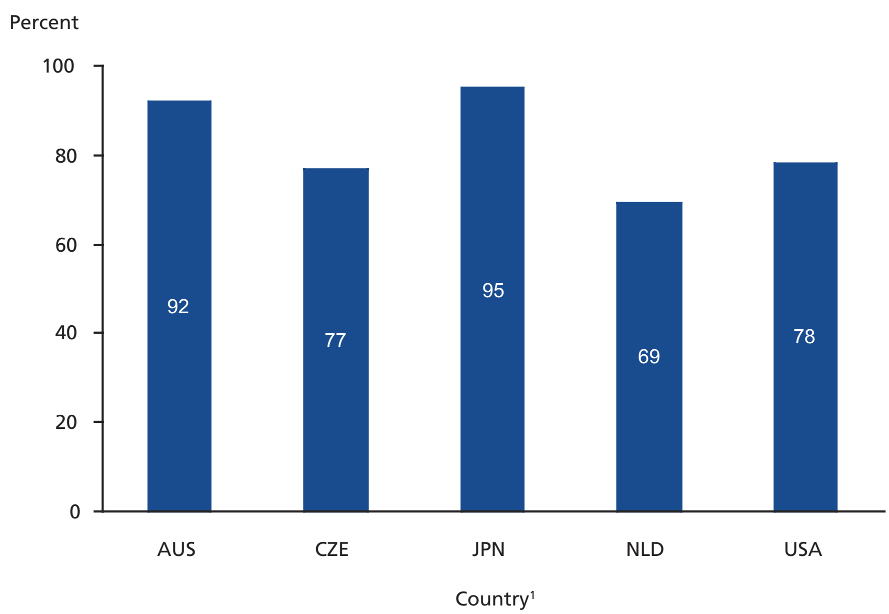

[1] AUS=Australia; CZE=Czech Republic; JPN=Japan; NLD=Netherlands; and USA=United States.
NOTE: CZE>JPN. Analysis is limited to public talk time. The above category was not applied to non-public segments of the lesson because of the nature of independent work and the limitations of the video methodology. During non-public talk segments, students were typically working independently on a set of tasks that may involve different types of knowledge.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study (TIMSS), Video Study, 1999.

**FIGURE 4.5. Average percentage of public talk time in eighth-grade science lessons devoted to real-life issues, by country: 1999**




[1] AUS=Australia; CZE=Czech Republic; JPN=Japan; NLD=Netherlands; and USA=United States.
NOTE: CZE, NLD, USA>JPN. Analysis is limited to public talk time. The above category was not applied to non-public segments of the lesson because of the nature of independent work and the limitations of the video methodology. During non-public talk segments, students were typically working independently on a set of tasks that may involve different types of knowledge.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study (TIMSS), Video Study, 1999.

**FIGURE 4.6. Percentage of eighth-grade science lessons that addressed procedural and experimental knowledge during public talk, by country: 1999**

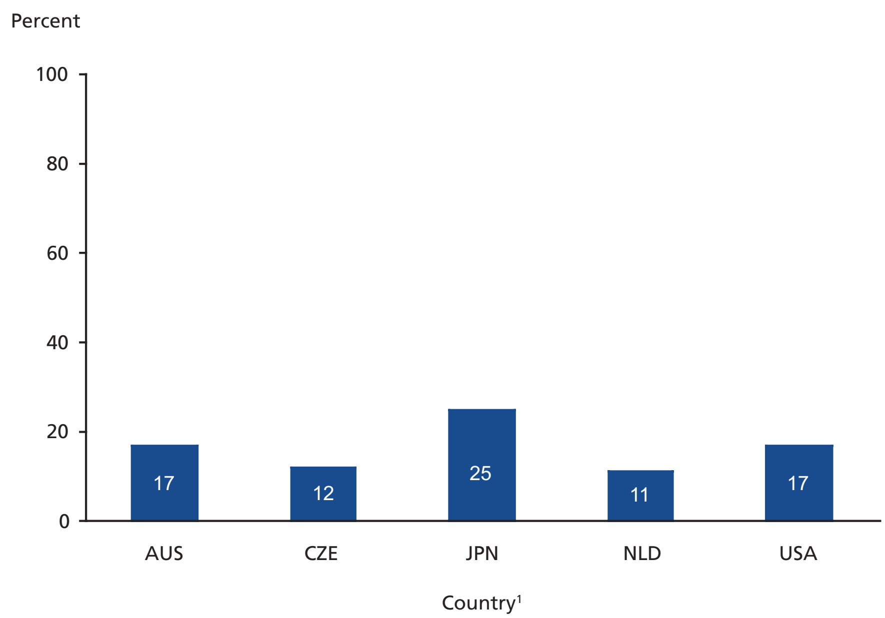



[1]AUS=Australia; CZE=Czech Republic; JPN=Japan; NLD=Netherlands; and USA=United States.
NOTE: AUS>NLD; JPN>CZE, NLD. Analysis is limited to public talk time. The above category was not applied to non-public segments of the lesson because of the nature of independent work and the limitations of the video methodology. During non-public talk segments, students were typically working independently on a set of tasks that may involve different types of knowledge.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study (TIMSS), Video Study, 1999.

## Procedural and Experimental Knowledge

- Across the five participating countries, at least 69 percent of the eighth-grade science lessons publicly addressed procedural and experimental knowledge (figure 4.6).
- Japanese science lessons devoted more time, on average, to publicly addressing procedural and experimental knowledge than lessons in each of the other countries (figure 4.7). Thus, although Australian and Japanese lessons were not found to differ measurably in the amount of time spent on independent practical activities (see chapter 3, figure 3.7), they varied in the amount of time allocated for public talk about procedures and experimental knowledge.

**Figure 4.7. Average percentage of public talk time in eighth-grade science lessons devoted to discussion of procedural and experimental knowledge, by country: 1999**

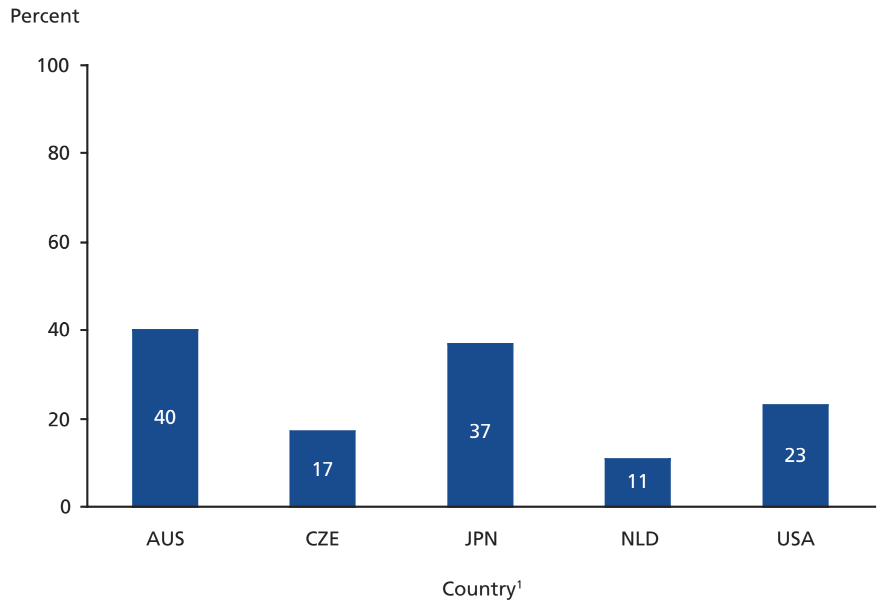



[1] AUS=Australia; CZE=Czech Republic; JPN=Japan; NLD=Netherlands; and USA=United States.
NOTE: JPN>AUS, CZE, NLD, USA. Analysis is limited to public talk time. The above category was not applied to non-public segments of the lesson because of the nature of independent work and the limitations of the video methodology. During non-public talk segments, students were typically working independently on a set of tasks that may involve different types of knowledge.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study (TIMSS), Video Study, 1999.

## Classroom Safety Knowledge

- Across the participating countries, the percentages of eighth-grade science lessons that publicly addressed information related to safety practices ranged from 11 percent in the Netherlands to 40 percent in Australia (figure 4.8).
- Across all of the countries, the average proportion of public talk time devoted to safety information was no more than 2 percent, suggesting that when teachers addressed safety knowledge, it was brief (data not shown).

**FIGURE 4.8. Percentage of eighth-grade science lessons that addressed classroom safety knowledge during public talk, by country: 1999**




[1] AUS=Australia; CZE=Czech Republic; JPN=Japan; NLD=Netherlands; and USA=United States.
NOTE: AUS>CZE, NLD; JPN>NLD. Analysis is limited to public talk time. The above category was not applied to non-public segments of the lesson because of the nature of independent work and the limitations of the video methodology. During non-public talk segments, students were typically working independently on a set of tasks that may involve different types of knowledge.
SOURCE: U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study (TIMSS), Video Study, 1999.

## Nature of Science Knowledge

- Across the countries, the percentages of eighth-grade science lessons that contained any publicly addressed information related to the nature of science ranged from 4 percent in Australia to 6 percent in the United States with too few cases in the Czech Republic to be reported (data not shown). Science lessons in the countries allocated no more than 1 percent of public talk time to discussions of the nature of science (data not shown).

## Meta-Cognitive Knowledge

- The percentage of eighth-grade science lessons that contained any public talk about meta-cognitive strategies ranged from 17 percent in Japan to 24 percent in the United States. On average, no more than 1 percent of public talk time was allotted to the discussion of meta-cognitive strategies during science lessons (data not shown).

## Summary

This chapter presented analyses of types of science knowledge that students had opportunities to learn during the public portion of the lessons that were presented. Among the key findings of this chapter is that all of the countries appeared to emphasize certain science disciplines and science topics except for the United States. Countries also differed in their emphasis on types of science knowledge. The Czech Republic provided more time to publicly discuss canonical knowledge, and Japan provided more time to discussing procedural and experimental knowledge than all the other countries. The Czech Republic, the Netherlands, and the United States emphasized knowledge about real-life issues more than did Japan. Each of the countries allocated relatively little time to discussing the nature of science, meta-cognitive strategies, and safety strategies.