Chapter One

Introduction

A. Background and Purpose of the Study

In 2000, the National Science Foundation supported the fourth in a series of surveys through a grant to Horizon Research, Inc. (HRI). The first survey was conducted in 1977 as part of a major assessment of science and mathematics education consisting of a comprehensive review of the literature; case studies of 11 districts throughout the United States; and a national survey of teachers, principals, and district and state personnel. A second survey of teachers and principals was conducted in 1985–86 to identify trends since 1977, and a third survey was conducted in 1993.

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

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

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

- To what extent do teachers support reform notions embodied in the National Research Council's *National Science Education Standards* and the National Council of Teachers of Mathematics' *Principles and Standards for School Mathematics*?

- What are the barriers to effective and equitable science and mathematics education?

The design and implementation of the 2000 National Survey of Science and Mathematics Education involved developing a sampling strategy and selecting samples of schools and teachers; developing and field testing survey instruments; collecting data from sample members; and preparing data files and analyzing the data. These activities are described in the following sections. The final section of this chapter outlines the contents of the remainder of the report.

B. Sample Design and Sampling Error Considerations

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

The sample design involved clustering and stratification prior to sample selection. The first stage units consisted of elementary and secondary schools. Science and mathematics teachers constituted the second stage units. The target sample sizes were designed to be large enough to allow sub-domain estimates such as for particular regions or types of community.

The sampling frame for the school sample was constructed from the Quality Education Data, Inc. (QED) database, which includes school name and address and information about the school needed for stratification and sample selection. The sampling frame for the teacher sample was constructed from lists provided by sample schools, identifying current teachers and the specific science and mathematics subjects they were teaching.

Since biology is by far the most common science course at the high school level, selecting a random sample of science teachers would result in a much larger number of biology teachers than chemistry or physics teachers. Similarly, random selection of mathematics teachers might result in a smaller than desired sample of teachers of advanced mathematics courses. In order to ensure that the sample would include a sufficient number of advanced science and mathematics teachers for separate analysis, information on teaching assignments was used to create separate domains, e.g., for teachers of chemistry and physics, and sampling rates were adjusted by domain.

The study design included obtaining in-depth information from each teacher about curriculum and instruction in a single, randomly selected class. Most elementary teachers were reported by their principals to teach in self-contained classrooms, i.e., they are responsible for teaching all academic subjects to a single group of students. Each such sample teacher was randomly assigned to one of two groups—science or mathematics—and received a questionnaire specific to that subject. Most secondary teachers in the sample taught several classes of a single subject; some taught both science and mathematics. For each such teacher, one class was randomly selected. For example, a teacher who taught two classes of science and three classes of mathematics each day might have been asked to answer questions about his first or second science class or his first, second, or third mathematics class of the day.

Whenever a sample is anything other than a simple random sample of a population, the results must be weighted to take the sample design into account. In the 2000 Survey, the weight for each respondent was calculated as the inverse of the probability of selecting the individual into the sample multiplied by a non-response adjustment factor.[1] In the case of data about a randomly selected class, the teacher weight was adjusted to reflect the number of classes taught, and therefore, the probability of a particular class being selected. Detailed information about the sample design, weighting procedures, and non-response adjustments used in the 2000 National Survey of Science and Mathematics Education is included in Appendix A. All data presented in this report are weighted.

The results of any survey based on a sample of a population (rather than on the entire population) are subject to sampling variability. The sampling error (or standard error) provides a measure of the range within which a sample estimate can be expected to fall a certain proportion of the time. For example, it may be estimated that 7 percent of all grade K–4 mathematics lessons involve the use of computers. If it is determined that the sampling error for this estimate was 1 percent, then according to the Central Limit Theorem, 95 percent of all possible samples of that same size selected in the same way would yield calculator usage estimates between 5 percent and 9 percent (that is, 7 percent ±2 standard error units).

The decision to obtain information from a sample rather than from the entire population is made in the interest of reducing costs, in terms of both money and the burden on the population to be surveyed. The particular sample design chosen is the one which is expected to yield the most accurate information for the least cost. It is important to realize that, other things being equal, estimates based on small sample sizes are subject to larger standard errors than those based on large samples. Also, for the same sample design and sample size, the closer a percentage is to zero or 100, the smaller the standard error. The standard errors for the estimates presented in this report are included in parentheses in the tables. The narrative sections of the report generally point out only those differences which are substantial as well as statistically significant at the 0.05 level or beyond.

C. Instrument Development

Since a primary purpose of the 2000 National Survey of Science and Mathematics Education was to identify trends in science and mathematics education, the process of developing survey instruments began with the questionnaires that had been used in the earlier national surveys, in 1977, 1985–86, and 1993. The project Advisory Panel, comprised of experienced researchers in science and mathematics education, reviewed these questionnaires and made recommendations about retaining or deleting particular items. Additional items needed to provide important information about the current status of science and mathematics education were also considered.

Preliminary drafts of the questionnaires were sent to a number of professional organizations for review; these included the National Science Teachers Association, the National Council of

[1] The aim of non-response adjustments is to reduce possible bias by distributing the non-respondent weights among the respondents expected to be most similar to these non-respondents. In this study, adjustment was made by region and by urbanicity of the school.

Teachers of Mathematics, the National Education Association, the American Federation of Teachers, and the National Catholic Education Association.

The Education Information Advisory Committee (EIAC) also played an important role in the instrument development process. This committee was established by the Council of Chief State School Officers to reduce the burden of data collection efforts on local education agencies; most state commissioners of education will not approve a survey unless it is first endorsed by EIAC. Horizon Research, Inc. worked with members of the EIAC committee throughout the planning stages of this project to make sure that the disruption to school activities and the burden on schools and teachers would be kept to a minimum.

The survey instruments were revised based on feedback from the various reviewers, field tested, and revised again. The instrument development process was a lengthy one, constantly compromising between information needs and data collection constraints. There were several iterations of field testing and revision to help ensure that individual items were clear and unambiguous and that the survey as a whole would provide the necessary information with the least possible burden on participants. Copies of the survey questionnaires are included in Appendix B.

D. Data Collection

Once the Education Information Advisory Committee had approved the study design, instruments, and procedures, the data collection subcontractor (Westat, Inc.) proceeded with securing permission from education officials. First, notification letters were mailed to the Chief State School Officers, identifying the schools in the state that had been selected for the survey. Similar letters were subsequently mailed to superintendents of districts including sampled public schools and diocesan offices of sampled Catholic schools. (Information about this pre-survey mail-out is included in Appendix C.) Copies of the survey instruments and additional information about the study were provided when requested.

Principals were asked to provide demographic information about the students in the school; the names of the science and mathematics department heads or other individuals who would be able to provide information about the science and mathematics programs in the school; and a list of all teachers responsible for teaching science and/or mathematics to one or more classes. The response rate at the school level was 73 percent.

An incentive system was developed to encourage school and teacher participation in the survey. Each school was given a credit of $50 towards the purchase of science and mathematics education materials; the amount was augmented by $15 for each responding teacher. At the completion of the data collection phase, schools were sent vouchers that they could use for purchasing professional publications, calculators, science activity books, kits, etc. from a catalogue developed for this study.

Survey mailings to teachers began in March 2000. In addition to the incentives described, phone calls and additional mailings of survey materials were used to encourage non-respondents to complete the questionnaires. In the fall of 2000, a final questionnaire mailing was sent to non-respondent teachers. Over the summer, some teachers left the schools at which they taught when they were originally sampled. If these teachers were considered ineligible for the study, the teacher response rate was 74 percent. When they were included as non-respondents, the response rate was 67 percent. The final response rate for the school program questionnaires was 79 percent. A more detailed description of the data collection procedures is included in Appendix D.

E. File Preparation and Analysis

Completed questionnaires were recorded in the data receipt system and routed to editing and coding. Manual edits were used to identify missing information and obvious out-of-range answers; to identify and, if possible, resolve multiple responses; and to make a number of consistency checks. When necessary, respondents were re-contacted and asked to clarify and/or complete responses to key items. After data entry, machine edits were performed to check for out-of-range answers, adherence to skip patterns, and logical inconsistencies, and weights were added to the data files. All population estimates presented in this report were computed using weighted data.

F. Outline of This Report

This report of the 2000 National Survey of Science and Mathematics Education is organized into major topical areas. In most cases, results are presented for groups of teachers categorized by grade ranges—grades K–4, 5–8, and 9–12. The definitions of these categories and other reporting variables used in this report are included in Appendix E.

Chapter Two focuses on science and mathematics teacher backgrounds and beliefs. Basic demographic data are presented along with information about course background, perceptions of preparedness, and pedagogical beliefs. Chapter Three examines data on the professional status of teachers, including their perceptions of their autonomy in making curriculum and instructional decisions, and their opportunities for continued professional development.

Chapter Four presents information about the time spent on science and mathematics instruction in the elementary grades, and about science and mathematics course offerings at the secondary level. Chapter Five examines the instructional objectives of science and mathematics classes, and the activities used to achieve these objectives, followed by a discussion of the availability and use of various types of instructional resources in Chapter Six. Finally, Chapter Seven presents data about a number of factors which are likely to affect science and mathematics instruction, including school-wide programs, practices, and problems.