CHAPTER ONE

Introduction

Background and Purpose of the Study

In 2012, the National Science Foundation supported the fifth in a series of national surveys of science and mathematics education 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, a third survey was conducted in 1993, and a fourth in 2000.

The 2012 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 7,752 science and mathematics teachers in schools across the United States participated in this survey. The research questions addressed by the survey are:

1. To what extent do science and mathematics instruction and ongoing assessment mirror current understanding of learning?
2. What influences teachers' decisions about content and pedagogy?
3. What are the characteristics of the science/mathematics teaching force in terms of race, gender, age, content background, beliefs about teaching and learning, and perceptions of preparedness?
4. What are the most commonly used textbooks/programs, and how are they used?
5. What formal and informal opportunities do science/mathematics teachers have for ongoing development of their knowledge and skills?
6. How are resources for science/mathematics education, including well-prepared teachers and course offerings, distributed among schools in different types of communities and different socioeconomic levels?

The design and implementation of the 2012 National Survey involved developing a sampling strategy and selecting samples of schools and teachers, developing and piloting 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.

Sample Design and Sampling Error Considerations

The 2012 National Survey 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 Common Core of Data and Private School Survey databases—programs of the U.S. Department of Education's National Center for Education Statistics—which include 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.

As 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 were 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.

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 2012 National 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 2012 National Survey is included in Appendix A.

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 elementary 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 computer usage estimates between 5 percent and 9 percent (that is, 7 percent ± 2 standard error units).

In survey research, 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 that 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 that are substantial as well as statistically significant at the 0.05 level.[2] All population estimates presented in this report were computed using weighted data.

Instrument Development

As one purpose of the 2012 National Survey 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, 1993, and 2000. The project Advisory Board, 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.

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[1] The aim of non-response adjustments is to reduce possible bias by distributing the non-respondents' weights among the respondents expected to be most similar to these non-respondents. In this study, adjustment was made by region, school metro status, grade level, type (public, catholic, other private), and percent minority enrollment.

[2] The False Discovery Rate was used to control the Type I error rate when comparing multiple groups on the same outcome. Benjamini, Y. and Hochberg, Y. (1995). Controlling the false discovery rate: A practical and powerful approach to multiple testing. *Journal of the Royal Statistical Society*, B, 57, 289–300.

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

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, including rounds of cognitive interviews with teachers 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 questionnaires are included in Appendix B.

Data Collection

HRI secured permission for the study from education officials at various levels. First, notification letters were mailed to the Chief State School Officers. Similar letters were subsequently mailed to superintendents of districts including sampled public schools and diocesan offices of sampled Catholic schools, identifying the schools in the district/diocese that had been selected for the survey. (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 log onto the study website and designate a school contact person or "school coordinator." The school coordinator designation page was designed to confirm the principal's contact information, as well as to obtain the name, title, phone number, and email address of the coordinator. Of the 2,000 target slots, 1,504 schools were successfully recruited and 35 were ineligible (e.g., closed or merged with another school) for a response rate of 77 percent.

An incentive system was developed to encourage school and teacher participation in the survey. School coordinators were offered an honorarium of up to $200 ($100 for completing a teacher list and school questionnaire, $15 for completing each program questionnaire (optional), and $10 for each completed teacher questionnaire). Teachers were offered a $25 honorarium for completing the teacher questionnaire.

Survey invitation letters were mailed to teachers beginning in February 2012. In addition to the incentives described, phone calls and emails to school coordinators were used to encourage non-respondents to complete the questionnaires. In May 2012, a final questionnaire invitation mailing was sent to teachers who had not yet completed their questionnaires. The teacher response rate was 77 percent. The response rate for the school program questionnaires was 83 percent. A detailed description of the data collection procedures is included in Appendix D.

Outline of This Report

This report of the 2012 National Survey is organized into major topical areas. In most cases, results are presented for groups of teachers categorized by grade level—elementary, middle, and high. In addition, factor analysis was used to create several composite variables related to key constructs measured on the questionnaires. Composite variables, which are more reliable than individual survey items, were computed to have a minimum possible value of 0 and a maximum possible value of 100. The definitions of these 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 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 that are likely to affect science and mathematics instruction, including school-wide programs, practices, and problems.

In addition, each chapter contains a set of "equity tables." These tables show the distribution of key outcomes across schools and classes of different demographic characteristics. For these tables, data from the program questionnaires are examined by four school-level factors: percentage of students eligible for free/reduced-price lunch (FRL), school size, community type, and region. Data from the teacher questionnaires were examined by an additional two factors: prior achievement level of students in the randomly selected class, and percentage of non-Asian minority students in the randomly selected class. Although the specific equity factors displayed in the body of the report vary by outcome, tables showing each examined outcome by all relevant equity factors are included in Appendix F.