Handbook of Research on Science Teacher Education

Edited by Julie A. Luft
and M. Gail Jones

ROUTLEDGE

HANDBOOK OF RESEARCH ON SCIENCE TEACHER EDUCATION

This groundbreaking handbook offers a contemporary and thorough review of research relating directly to the preparation, induction, and career long professional learning of K–12 science teachers.

Through critical and concise chapters, this volume provides essential insights into science teacher education that range from their learning as individuals to the programs that cultivate their knowledge and practices. Each chapter is a current review of research that depicts the area and then points to empirically based conclusions or suggestions for science teacher educators or educational researchers. Issues associated with equity are embedded within each chapter. Drawing on the work of over 100 contributors from across the globe, this handbook has 35 chapters that cover established, emergent, diverse, and pioneering areas of research, including:

- Research methods and methodologies in science teacher education, including discussions of the purpose of science teacher education research and equitable perspectives;
- Formal and informal teacher education programs that span from early childhood educators to the complexity of preparation, to the role of informal settings such as museums;
- Continuous professional learning of science teachers that supports building cultural responsiveness and teacher leadership;
- Core topics in science teacher education that focus on teacher knowledge, educative curricula, and working with all students; and
- Emerging areas in science teacher education such as STEM education, global education, and identity development.

This comprehensive, in-depth text will be central to the work of science teacher educators, researchers in the field of science education, and all those who work closely with science teachers.

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THE CONTRIBUTION OF LARGE EDUCATIONAL SURVEYS TO SCIENCE TEACHER EDUCATION RESEARCH

Robert H. Tai, Joseph A. Taylor, Vijay Reddy, and Eric R. Banilower

Introduction

The importance of large-scale data sets in educational research is grounded in the necessity to account for representativeness, inclusiveness, and diversity in a population in order to enact the proper recommendations for and implementation of policies and standardization of educational practices. With respect to science teacher education research, differences in access to educational resources, among other factors, may have a profound impact on the effectiveness of particular pedagogical approaches. Large-scale nationally representative data can be used to uncover trends that elucidate disparities that might otherwise go undocumented. At times, the analysis of these types of data sets is the only means to offer convincing evidence of the existence of broad-based inequities that might influence policy makers to effect change.

Large-scale data set analyses are not a replacement for other research approaches, but rather, have a synergetic relationship with them, each extending the reach of the other when used in concert. Findings from analyses of large-scale nationally representative data sets offer insights that may serve as a guide for further investigation using qualitative methods. Other times, findings from studies using other methods, including qualitative approaches, may be examined using large-scale data sets to determine the pervasiveness of these findings within a population. While this chapter focuses on large-scale educational surveys implemented by institutional organizations, surveys developed and implemented by independent researchers also play important roles. Indeed, large-scale educational surveys and independent researcher-developed surveys each have different roles that may inform and enlighten the other, and overall push the boundaries of our understanding of impactful pedagogical practices to inform science teacher education.

This chapter will discuss nationally representative studies carried out under the auspices of governmental agencies or organizations. The chapter begins with an overview of some large-scale data sets that are currently available for secondary analysis. This discussion will provide examples of the types of data that are collected and explore questions relevant to science teacher education research. Next, the chapter will provide an overview of five existing large educational surveys available to researchers. These selected data resources serve as exemplars of large-scale nationally representative data sets both through both sample size and through robustness and comprehensiveness of data collection. The chapter will conclude with an example of an analysis from the South African educational context. The aim of this example is to give readers some sense of the potential for large-scale data analysis as a research approach.

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Large-Scale Nationally Representative Data Sets

This section provides descriptions of some broadly useful large-scale data sets available to researchers interested in studying science teacher education. Five large-scale nationally representative data sets were selected as exemplars. They include: Trends in International Mathematics and Science Surveys (TIMSS); National Teachers and Principals Survey (NTPS); National Assessment of Education Progress (NAEP); National Survey of Science and Mathematics Education (NSSME); and High School Longitudinal Study of 2009 (HSLS:2009). Each of these data sets offers unique characteristics. TIMSS is a multi-national study that offers researchers the opportunity to focus on a specific nation or to perform an international comparison. TIMSS national data sets are all designed to be nationally representative for each participating nation and are designed to provide trend measures. NTPS is a national survey that specifically focuses on teachers and principals in United States (US) schools. NAEP is a cross sectional data set that focuses on science and mathematics indicators of attainment in US schools that allows for multi-year comparisons. NSSME surveys schools and teachers in multiple years in elementary, middle, and high schools in the US. HSLS:2009 is a US longitudinal study that tracks youth over time with follow-up surveys in 2012 and 2016. NTPS is a US survey specific to teachers and principals. While most surveys focus mainly on student outcomes, all include specific teacher questionnaires. While only HSLS:2009 is longitudinal in design, the other four surveys have multi-year cross sectional data.

TIMSS, NTPS, NAEP, NSSME, and HSLS:2009 are exemplar data resources for a number of reasons. They offer the sample size and sample diversity to give researchers the statistical power and flexibility to apply many different analytical approaches and reach robust results. These data resources also collect data at different levels, many times from students to teachers to principals/schools to parents. This array of different surveyed subgroups widens the research options of science teacher education researchers. Finally, these data resources have the backing of the wider research community, having been vetted through peer review.

Table 2.1 displays some questionnaire items from the teacher surveys from each of the five data sets used as exemplars in this chapter. The survey items displayed in Table 2.1 offer readers a glimpse of the variety of potential research topics that these data sets may be used to examine. The questionnaire items span five topics: teacher educational background and training, professional development experiences, curriculum and instruction practices, teachers' attitudes and opinions, and teachers' views on school environment. Yet, there are many more topics in addition to these listed here.

Variations for many specific questionnaire items may appear across a number of data sets. An example is the item from HSLS:2009, "How much emphasis are you placing on each of the following objectives? Increasing students' interest in science." This also appears in NSSME as "Think about your plans for this class for the entire course/year. By the end of the course/year, how much emphasis will each of the following student objectives receive? Increasing students' interest in science." Both items have identical four-choice response options. While there is some overlap in questionnaire items, these data sets are far from identical. The overlap gives researchers multiple analysis options for pursuing their research questions. If a specific combination of variables or respondent characteristics for addressing a researcher's questions is not available in a given data set, a different data set may contain the necessary combination. For example, the HSLS:2009 survey item was administered to teachers at the 9th-grade level in 2009, while the NSSME survey was administered in 2018 to K–12th-grade teachers.

The structure of the large-scale nationally representative data resources and the breadth of their surveys allow researchers to answer a variety of different questions. The structures of these types of data resources are typically consistent over a time span of years. For example, the same form and format of many questions are used in different surveys from year to year. This characteristic allows for the study of educational trends over time. Science teacher education researchers have the capacity to compare and contrast differences across spans of time, which opens up numerous options for

Table 2.1 Examples of science teacher survey topics and questionnaire items

Topics	*Questionnaire Item*	*Source Survey*
Educational Background and Training	BEFORE your first year of teaching, did you take any graduate or undergraduate courses which taught you – • Classroom management techniques? • How to assess learning? • How to use student performance data to inform instruction? • How to serve students from diverse economic backgrounds?	NTPS 2020–2021
Professional Development	How frequently, if at all, did you collaborate with other teachers on issues of instruction excluding administrative meetings?	NTPS 2017–2018
	Did you receive the following kinds of support in your first year of teaching? • Reduced teaching schedule or number of preparations. • Release time to participate in support activities for new or beginning teachers.	NTPS 2020–2021
Curriculum and Instructional Practice	How often do you ask your students to interpret data from experiments or investigations?	TIMSS 2019
	How often do your science students work with other students on a science project or activity?	NAEP 2018 Pilot
	How often do your science students figure out different ways to solve a science problem?	NAEP 2018 Pilot
	Think about your plans for this class for the entire course/year. By the end of the course/year, how much emphasis will each of the following student objectives receive? • Learning science vocabulary and/or facts • Understanding science concepts • Learning about real-life applications of science/engineering	NSSME 2018
	How much control do you have over each of the following aspects of science instruction in this class? • Determining course goals and objectives • Selecting content, topics, and skills to be taught • Selecting teaching techniques	NSSME 2018
	How much emphasis are you placing on each of the following objectives? • Increasing students' interest in science • Teaching students basic science concepts • Preparing students for further study in science	HSLS 2009
Attitudes and Opinions	To what extent do you agree or disagree with each of the following statements as it applies to your instruction? • If you really try hard, you can get through to even the most difficult or unmotivated students. • When it comes right down to it, you really cannot do much because most of a student's motivation and performance depends on their home environment.	HSLS 2009
	How often do you feel the following way about being a teacher? • I find my work full of meaning and purpose • I am enthusiastic about my job	TIMSS 2019

Topics	*Questionnaire Item*	*Source Survey*
Views on School Environment	Thinking about your current school, indicate the extent to which you agree or disagree with each of the following statements. • This school's security policies and practices are sufficient • I feel safe at this school	TIMSS 2019
	How would you characterize each of the following within your school? • Parental support for student achievement • Collaboration between school leadership (including master teachers) and teachers to plan instruction	TIMSS 2019

Note: While source surveys are cited, many times similar questionnaire items appear in the other surveys.

Sources: Trends in International Mathematics and Science Surveys (IEA, 2019); National Teachers and Principals Survey (NCES, 2017a, 2017b); National Assessment of Education Progress (NAEP, 2018a, 2018b, 2018c, 2018d, 2020); High School Longitudinal Study of 2009 (NCES, 2020); National Survey of Science and Mathematics Education (NSSME).

analysis. These data resources are also designed to be broadly inclusive of various subpopulations. For researchers interested in examining differences between rural and suburban science teacher classroom experiences, or for researchers with questions about regional and national differences in science teacher professional development, large-scale data resources contain the information to make these comparisons. These data resources also have sample weights that allow researchers to produce findings that are nationally representative. Sample weighting allows the statistical analysis to account for each subgroup within the large-scale data set in a manner that reflects its share of the national population. This capacity means that research findings have the robustness necessary to allow researchers to compare differences in educational policies and practices, and to claim that significant findings represent national trends.

Trends in International Mathematics and Science Surveys (TIMSS)

TIMSS contains data on students, teachers, school principals, and parents. Initiated in 1995 as the Third International Mathematics and Science Survey, TIMSS has collected data through surveys in 1995, 1999, 2003, 2007, 2011, 2015, and 2019. The 2019 survey collected data from 64 participating countries primarily in grades 4 and 8, though some countries surveyed students in grades 5 and 9.

While much focus has been placed on TIMSS Student Questionnaire data, TIMSS also includes teacher surveys about school resources and educational approaches, including curriculum and instructional practices, as well as parent surveys about home learning contexts and school surveys. Additional surveyed topics include teacher preparation and experience, instructional practices and strategies, instructional clarity, classroom climate, use of technology in instruction, and challenges faced by teachers. The most recently available data came from the TIMSS 2019 Teacher Questionnaires.

The data collection approaches used in TIMSS follow a study-wide data collection protocol that is designed to obtain nationally representative samplings of students from all participating nations. Data collected from teachers and schools are associated with the participating students. Users should closely examine the technical details of data collection for each nation available in the *Methods and Procedures: TIMSS 2019 Technical Report* (Martin et al., 2020). The capacity for producing nationally representative analyses is generally good, but users should examine the sampling methods and procedures for each country as relevant to their specific analyses.

National Teacher and Principal Survey (NTPS)

The NTPS describes the national context of elementary and secondary education in the United States. Formally known as the Schools and Staffing Survey, the NTPS is administered and scored by the National Center for Education Statistics (NCES) every 2 to 3 years (NCES, 2020a). The NTPS sample is a nationally representative sample of teachers and principals. While sample sizes vary by administration year, samples of over 4000 randomly selected teachers or principals is typical. The 2015–16 administration of the NTPS had approximately 8,300 respondents according to a publicly available suite of data analysis tools called *DataLab* (NCES, 2020b). This suite of tools has an integrated capacity to handle weighting and allows for basic inferential statistical analysis (logistic or linear regression analyses) for testing multiple main effects.

However, there are some drawbacks. The reader should note that for all the NCES data sets, analyses must employ the provided sample weights. Additionally, for restricted-use or public-use raw data, appropriate use of weights is the responsibility of the researcher, although NCES's *DataLab* and its associated tools have an integrated capacity to handle weighting and allow for basic inferential statistical analysis (logistic or linear regression analyses) for testing multiple main effects. However, *DataLab* lacks the capacity for testing interaction effects or centering variables for enhanced interpretation, and analyzes only public access data, which may not contain all of the researcher's desired variables.

The NTPS queries teachers on their preparation, teaching assignments, and demographic characteristics. Some administrations of NTPS include questions about teachers' working conditions, professional development opportunities, and evaluation experiences. Specifically, teachers provide information about their race, sex, age, teaching experience, degree attainment, undergraduate and graduate preparation, class sizes, salary, evaluation frequency and perceptions of the evaluation process, and the frequency and nature of their professional development opportunities.

NTPS data support both descriptive analyses (e.g., proportions, central tendency) and associational (e.g., correlation, chi-squared, regression) analyses of teacher variables. These analyses leverage the two-stage (school, then teacher) random sampling process that results in a nationally representative sample of teachers.

National Assessment of Educational Progress (NAEP)

NAEP is a nationally representative, continuing evaluation of the US education system. Within NAEP, science assessment data are collected and used to measure student achievement in Earth and space science, physical science, and life science topics. In 2015, the most recent science assessment was administered to a nationally representative sample consisting of 115,400 students in grade 4, 110,900 students in grade 8, and 11,000 students in grade 12. Data and results are now available for the 2015 administration of NAEP Science.

Data from each of the achievement tests (for grades 4, 8, and 12) are accompanied by voluntary questionnaires administered to students, teachers, and school administrators. These additional surveys provide information on students' education background and demographic characteristics, school contextual information, and information on the nature of students' formal and informal learning experiences.

The NAEP teacher questionnaires collect helpful information about teachers and their teaching practices. This information falls in several key categories, including demographics, experience teaching and teaching science, certification level, degree attainment, disciplinary emphasis of undergraduate and graduate major/minor, nature and focus of professional development opportunities, available teaching resources, frequency with which they use selected instructional practices, and the extent to they emphasize selected instructional objectives.

NAEP analyses support correlation/regression-based analyses that examine the strength and direction of relationships between teacher characteristics or practices and student achievement. These analyses leverage the two-stage (school, then student) random sampling process that results in a nationally representative sample of students. Note that the teachers associated with these students are not randomly sampled within randomly selected schools. As such, researchers may report descriptive statistics on the available teacher variables but should not refer to those statistics as nationally representative.

High School Longitudinal Study of 2009 (HSLS:2009)

HSLS:2009 is a longitudinal study of a nationally representative sample of US students who were 9th graders in 2009. The sample includes over 23,000 students from 944 schools, their teachers, school administrators, and parents. Follow-up data collection occurred with these students in 2012 and 2016, assessing, among other things, post-secondary enrollment and career outcomes (e.g., STEM occupational intentions, employment/earnings expectations), respectively. Post-secondary transcripts for these students are now available. For most students, HSLS:2009 includes an achievement measure related to algebraic skills, reasoning, and problem solving at both 9th and 11th grades.

The HSLS:2009 student data are accompanied by questionnaire responses from science teachers. The teacher questionnaire collected data on teacher background characteristics including demographics (i.e., sex, race/ethnicity), degrees earned, certification, and post-secondary coursework. Other questionnaire sections queried teachers on their beliefs about teaching and their current school, as well as their beliefs about instruction and their science department. Teacher beliefs about their school or department include those about their current working conditions. Teacher beliefs about instruction include those pertaining to students and student learning.

HSLS:2009 data support correlation/regression-based analyses that examine the strength and direction of relationships between science teacher characteristics, or beliefs and student achievement in high school mathematics or other subsequent outcomes (e.g., post-secondary enrollment, career intentions). These analyses leverage the two-stage (school, then student) random sampling process that results in a nationally representative sample of students. Note that the teachers associated with HSLS:2009 students are not randomly sampled within randomly selected schools. Therefore, as with NAEP, researchers may report descriptive statistics on the available teacher variables but should not refer to those statistics as nationally representative.

National Survey of Science and Mathematics Education (NSSME)

The NSSME has periodically collected data about the status of the US K–12 science and mathematics education system, beginning in 1977, and then again in 1985–86, 1993, 2000, 2012, and 2018.[1] The 2018 iteration expanded the scope of the study to include a focus on computer science education, particularly at the high school level. The NSSME provides nationally representative information about the status of the system in the areas of teacher background and experience, instructional practices, the availability and use of instructional resources, and school policies and practices.

The 2018 NSSME+ (the plus symbol reflects the inclusion of computer science in the study) used a stratified two-stage random sampling approach. In the first stage, 2,000 elementary and secondary schools, public and private, were selected within strata (defined by grades served) with probability proportional to size. At the second stage, approximately 10,000 science and mathematics teachers were sampled at predetermined rates to ensure a sufficient sample size for domain estimates, such as region or community type. Computer science teachers were sampled with certainty to allow for national estimates, as their prevalence in secondary schools was much lower than science and mathematics teachers.

In 2018, the study collected data from 1,273 schools and 7,600 teachers (3,497 teachers of science, 3,814 teachers of mathematics, and 289 teachers of high school computer science). In addition to teacher questionnaires, program questionnaires (asking about subject-specific school practices and policies) were administered to each participating school – typically completed by a department chair, lead teacher, or school administrator.

De-identified data from the 2000, 2012, and 2018 iterations of the study are available for secondary analysis. The materials for each year include data from each questionnaire, a data dictionary, and guidance on how to compute standard errors for estimates given the sample design.

The NSSME program questionnaires collect data about several school-level factors, including courses offered, resources provided for instruction, programs and practices to encourage student interest and achievement, and school/district professional development practices. The school coordinator questionnaire collects data about the students served by the school, and, in 2018, included a series of items about induction supports offered for new teachers.

The NSSME teacher questionnaires collect a wide range of information about teachers, their teaching practices, and factors that may affect their teaching. The questionnaires ask about their preparation for teaching, beliefs about teaching and learning, perceptions of preparedness, and professional development experiences. For a randomly sampled class, teachers are also asked the extent to which instruction emphasizes various objectives, instructional strategies used, and homework and assessment practices. Lastly, the questionnaire asks about factors that may affect instruction, including the availability and use of different types of instructional materials and resources and the supportiveness of the school context.

The NSSME data allow researchers to examine many issues related to teacher education. For example, the data about classroom instruction could be used to identify areas of strength and need in the preservice preparation and in-service support of science teachers. The NSSME also provides a great deal of data about teacher professional development, including extent of participation and the nature of these experiences. Further, the NSSME allows researchers to examine relationships among a variety of factors such as teachers' preparation for teaching, their teaching practices, and the characteristics of the schools they work in. Because of the sampling method used, school, teacher, and classroom data are nationally representative when analyzed with the complex sample replicate weights included in the data sets.

Table 2.2 shows a summary of the data access and analytical software options for the five data resources discussed in this chapter.

An Example of Analysis: Using TIMSS Data from South Africa to Explore Science Teacher Education Research

In this section an analysis of TIMSS data is presented to illustrate how the analyzed data was used to inform South African science teacher education programs. South Africa has a national school curriculum, and all students are expected to achieve the same outcomes. Yet, students start school with vastly different levels of school readiness. It is these differences that heavily impact educational outcomes, and in particular, science teacher education. South Africa is one of 39 countries that participated in TIMSS 2019 at the grade 9 level. Established in 1994, South Africa is a young and diverse democracy in terms of its people, ethnicity and racial backgrounds, languages, politics, religions, social stratifications, and histories. The historical legacy of apartheid and racial discrimination has left South Africa with stubbornly high levels of inequity that mirror its deeply polarized society, with a small elite class (4%), a relatively small middle class (20%), and three-quarters of the population characterized as poor according to the World Bank (Sulla & Zikhali, 2018).

Table 2.2 Summary of data access and analysis software options for several large-scale data sets

Data Set	*Data Access*		*Commonly Used Analysis Software*
	Public-Use Data	*Restricted-Use Data*	
Trends in International Mathematics and Science Surveys	Available	Permission required	IDB Analyzer, R (R Core Team, 2020), SPSS® (IBM, 2020), Stata® (STATA, 2020), SAS®
National Teacher and Principal Survey	Available	Permission required	NCES Datalab, R, SPSS®, Stata®, SAS®
National Assessment of Educational Progress	Available	Permission required	NAEP Data Explorer, SPSS®, Stata®, SAS®, Ed*Survey* (AIR, 2020a), *AM* (AIR, 2020b)
High School Longitudinal Study of 2009	Available	Permission required	R, SPSS®, Stata®, SAS®
National Survey of Science and Mathematics Education	Available with term of use agreement	Not available	Wesvar, R, Stata®, SAS®

It is clear that education, and specifically science education, offers a path forward for the growth and development of a technically proficient workforce, as well as through the proliferation of scientific knowledge important to daily life. The South African educational aspiration is to improve the educational level of all students in schools and to decrease the achievement gaps between different groups. The 4-year TIMSS cycle offers a credible and trusted measure of science and mathematics achievements over time.

"Know your student" is an age-old maxim in teaching. Using the nationally representative TIMSS data, a picture is painted of students' current science achievement, and information regarding the resources and pedagogical practices of grade 9 South African science teachers is distilled.

Unequal Science Achievement

To address high levels of poverty and socioeconomic inequality, the South African state abolished school fees for students in poorer communities. These schools are known as "no-fee" schools, while schools where students pay fees are designated as "fee-paying" schools. Two-thirds of South African students attend no-fee schools and one-third attend fee-paying schools. Figure 2.1 compares grade 9 science achievement score averages and distribution in no-fee versus fee-paying schools. The comparison shows a 107-point gap in average science achievement. Considering that science proficiency is qualified by a score of 400, about two in three students in fee-paying schools, versus only one in four students in no-fee schools, demonstrated attainment of science proficiency. The challenge in preparing new teachers for these starkly different circumstances is immense, and it is critical that science teacher educators understand existing inequities and prepare their students accordingly. For full details of South African TIMSS 2019 achievement and the context of learning see Reddy et al. (2020).

Inequalities at Home Carry Over to Classrooms

Existing literature has shown that access to resources at home (e.g., Sirin, 2005) and school (e.g., van der Berg, 2008) are predictors of achievement. To better understand the underlying causes of these

Science	Average Scale Score (SE)
Public no-fee	335 (3.2)
Public fee-paying	422 (5.4)

Achievement Distribution

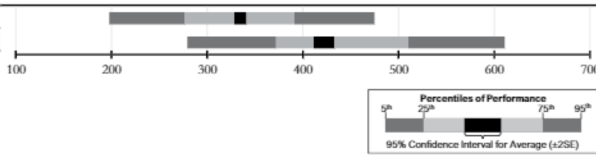

Figure 2.1 Science achievement scores for fee and no-fee schools and the corresponding achievement distribution

achievement differences, the conditions at home for students from fee-paying versus no-fee schools are examined. Figure 2.2 juxtaposes home conditions of students in the two types of South African schools to offer some insight into the differences in their lived experiences. The lack of running water in the home for more than one-third of no-fee school students presents a stark contrast to fee-paying school students and defines a clear difference in the educational focus of science teachers in these two educational environments.

The higher levels of parental education for students in fee-paying schools mean better parental support for learning than in no-fee schools. While the South African constitution protects the rights of the 11 official languages, schools have chosen the language of learning and teaching as either English or Afrikaans. The proficiency in the language of the test continues to be an epistemic barrier for the majority of students. Half the students in fee-paying schools, while only 16% in no-fee schools, say they frequently speak the language of the test at home (a proxy for test language proficiency). Data from the TIMSS 2019 Grade 8 Teacher Survey shows that among teachers, only 26% reported no students have difficulty understanding the language of instruction, while 74% reported at least "some" to "a lot."

These findings regarding language proficiency illustrate the power of large-scale data sets for identifying issues of equity in science education. In addition, while students develop knowledge about topics, they are also learning a new language; e.g., see National Academies of Sciences, Engineering, and Medicine (2018). Large-scale surveys can help track the diffusion of this knowledge through the education system. For example, a large-scale survey can assess teachers' access to and participation in professional learning on a topic, their preparedness to use and beliefs about the efficacy of instructional practices to support language learners, and their implementation of these practices. Further, with a study like TIMSS, large-scale studies can help track changes in student outcomes over time.

Figure 2.2 also shows student access to digital assets at home (69% for fee-paying versus 37% for no-fee students). The TIMSS Grade 8 Teacher Questionnaire data showed that only 10% of learners had access to computers or tablets in their science lessons (8% in no-fee schools and 15% in fee-paying schools). The lack of digital assets poses immense limitations on the pedagogical choices of science teachers. Yet the challenges facing science teachers and researchers are broader in scope than educating South Africa's youth without resources common in other countries. The larger issue is providing these youth with the requisite educational experiences necessary for them to participate in the modern global economy.

In the context of high-poverty levels, parents and society in general often view schools as institutions that can provide opportunities for students from poorer homes, and they attempt to level the playing field of educational success. Inequalities experienced by students at home continue to schools, with students in no-fee schools facing multiple inequalities.

Teaching and learning will be affected by the school conditions and the resources they have. On average, the class size for no-fee schools is 56 students compared to fee-paying schools at

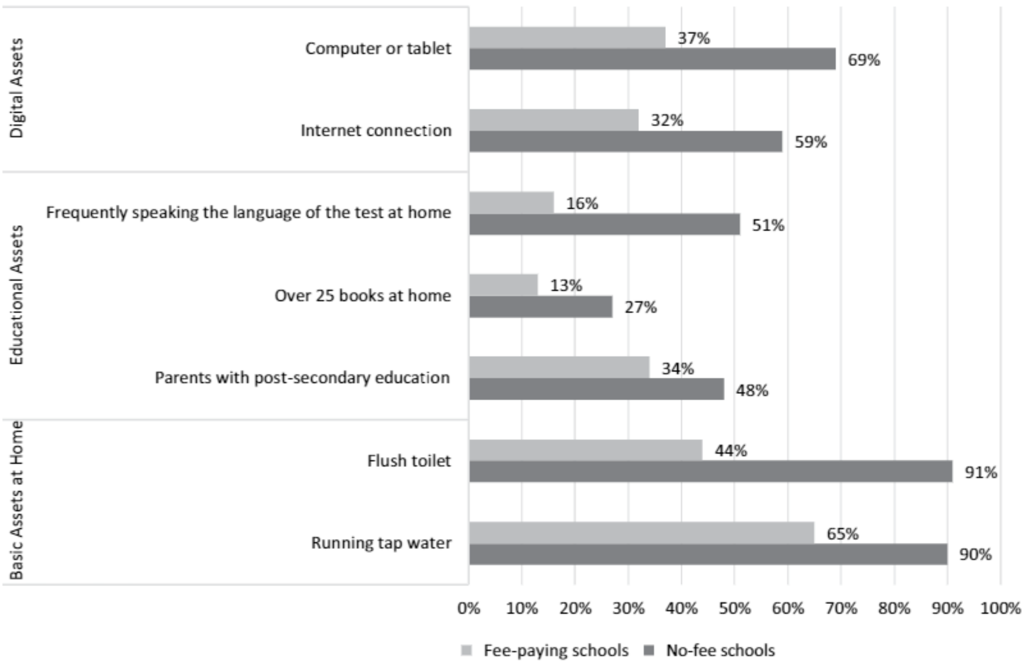

Figure 2.2 Percentage of students, in fee-paying and no-fee schools, having basic, educational, and digital assets at home

41 students (TIMSS 2019 data set). This 37% difference in class size from fee-paying classrooms to no-fee schools creates immense challenges for teachers. Inequalities in the two school types extend to the availability of science textbooks and workbooks as well, which is a key policy intervention from the state to equalize educational opportunities. Yet, there are still differences in students' access to science textbooks and workbooks in fee-paying and no-fee schools (Figure 2.3). Fewer than half the students in no-fee schools have a workbook or a textbook, compared with close to two-thirds of students in fee-paying schools.

The availability of laboratories and science equipment in a school is critical to conduct science experiments and investigations, an essential ingredient for the successful teaching and learning of the sciences. These are expensive resources, and only one-third of students in no-fee schools, compared to three-quarters of students in fee-paying schools, have access to a laboratory. The lessons given by teachers with and without a science laboratory space and equipment will be vastly different. This situation presents a challenge for science teacher education programs to determine how to prepare the next generation of new teachers to adapt and overcome a lack of resources. It is apparent from this analysis that science teacher education in South Africa should include pedagogy applying advanced technology, as well as pedagogy with no technology access. Recognizing this inequality of opportunity, and the impact it has, must be a serious consideration for teacher education programs.

Summary

Collectively, large-scale nationally representative data sets provide a wealth of analysis options for science teacher education research that may offer findings generalizable to the population. It is the responsibility of researchers to make candid assessments of the condition of science education. This type of data allows researchers to make assessments at a national level, as well as disaggregate data for

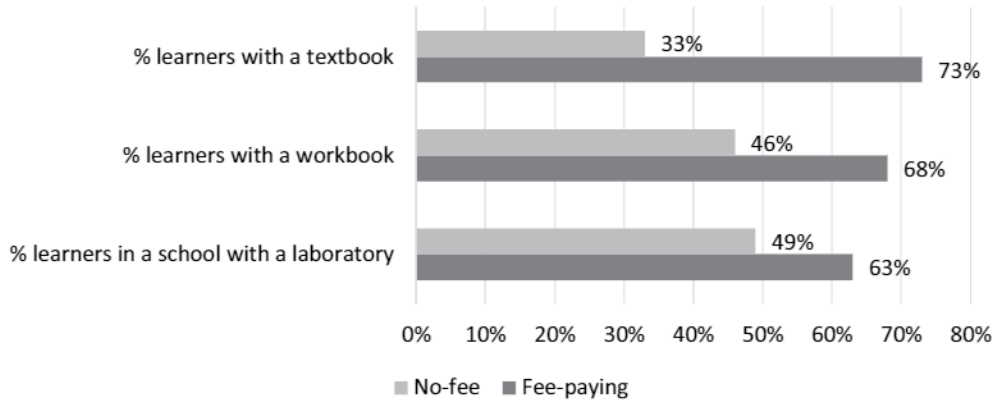

Figure 2.3 Resources in fee-paying and no-fee schools

important subgroup analyses. The aim of the example provided in this chapter speaks to this result. Data sets such as these described in this chapter may cast light on numerous topics, such as use and effectiveness of particular teaching practices, equity of common teaching practices, diversity in a nation's students and teaching workforce, typical working conditions for teachers, and resources available for teaching, among others.

Each data resource has its own focus and primary approach. For example, NTPS and NSSME provide descriptive information on teachers, their professional development experiences, teaching practices, and working conditions, while HSLS:2009 and NAEP Science offer more information linking teachers' and students' reported experiences. As a result, researchers seeking answers to research questions would be well served to examine a number of different data resources.

For some researchers, a lack of experience or training inhibits their engagement with these types of data resources. Professional development options are available. For example, in the United States, the National Center for Education Statistics (NCES) has developed a comprehensive *Distance Learning Dataset Training* (DLDT) system (NCES, 2021). This resource is an online tool that allows researchers to learn about NCES data products and assess the fit with their research needs. The modules in the DLDT cover each survey's design and specific analysis considerations. The International Association for the Evaluation of Educational Achievement (IEA) provides training and tutorials on the use of the TIMSS data.

Other researchers may be concerned about the shelf life of these data sets with release dates sometimes as many as 3 years after data collection. The fact remains that large-scale data sets focus on national-level trends, and these trends are more like the climate and less like the weather. While there may be local shifts, the climate of educational practice and policy outcomes remain stable and shift only slowly with time. In the years following publication of this volume, more data sets will follow, each holding important findings patiently waiting to be discovered by imaginative and determined researchers.

Note

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