

# TIMSS 2011 Contextual Framework

Chapter

3



# Chapter 3

## TIMSS 2011 Contextual Framework

### Overview

This chapter provides the foundation for the information that will be collected via the TIMSS background questionnaires given to the students themselves as well to their classroom teachers and school heads or principals. Participating countries also complete questionnaires about the national contexts and curriculum for instruction in mathematics and science. Because learning takes place within a context and not in isolation, TIMSS makes every attempt to collect information about the important factors that foster improved teaching and learning in mathematics and science. The questionnaires concentrate on procedures and practices that have been shown to be effective in increasing achievement in mathematics and science. In this way, countries can better evaluate their TIMSS results; in terms of the prevalence of the home or school situation or instructional practice in their country and its relationship with student achievement.

There are numerous contextual factors that affect students' learning. For example, type of school, school resources, instructional approaches, teacher characteristics, student attitudes, and home support for learning contribute heavily to student learning and achievement. For a fuller appreciation of what the TIMSS achievement results mean and how they may be used to improve student learning in mathematics and science, it is important to understand the contexts in which learning takes place. TIMSS in every cycle collects a range of information about these contexts for learning, together with assessing students' performance in

mathematics and science. Just as the mathematics and science frameworks describe what should be assessed in those areas, the contextual framework identifies the major characteristics of the educational and social contexts that will be studied with a view to improving student learning.

Students in their fourth or eighth year of schooling typically have gained most of their mathematics and science learning at school and home, influenced to some extent by experiences outside of school. School, classroom, and home environments that support each other can create extremely effective climates for learning. To reflect this situation, the *TIMSS 2011 Contextual Framework* encompasses four broad areas:

- National and Community Contexts
- School Contexts
- Classroom Contexts
- Student Characteristics and Attitudes

### The TIMSS Curriculum Model

Building on IEA's experience and the previous cycles of TIMSS, TIMSS 2011 uses the curriculum as a major organizing concept in considering how educational opportunities are provided, and the factors that influence how these opportunities are used effectively. TIMSS examines the curricular goals, how the educational system is organized to facilitate the implementation of these goals, and how effectively these goals are attained.

At the national and community level, for example, the value systems of the people, the population demographics, and the amount

of available resources can influence how much mathematics and science societies intend their students to learn and the contexts in which learning takes place. An effective school organization and a safe and cooperative school environment facilitate the implementation of the intended curriculum. That is also true for an educated and motivated teaching force, well equipped classrooms, and a supportive classroom atmosphere. Furthermore, effective teaching strategies, the availability and use of technology as well as coverage of the curricular content contribute to a successful attainment of the curricular goals.

Students vary in their prerequisite knowledge and skills and the support they receive from their homes as well as the motivation and interest to learn mathematics and science. Schools' and teachers' success in implementing the curriculum and contributing to student learning is influenced by the prerequisites that students themselves bring to the educational enterprise as well as their attitudes toward learning.

To better understand the contextual factors that affect students' learning in mathematics and science, TIMSS utilizes background information from a variety of sources. To provide information about the national contexts that shape the content and organization of the intended curriculum as well as political decision making processes, TIMSS publishes the TIMSS Encyclopedia (Mullis, Martin, Olson, Berger, Milne, & Stanco, 2008). The TIMSS 2011 Encyclopedia will be a collection of descriptions of mathematics and science education in the participating countries. It will also include an introduction that focuses on the national contexts for the support and implementation of mathematics and science curricula and policies across countries based on responses to curriculum questionnaires. To gather information about the school, classroom, and student factors associated with the delivery of mathematics and

science instruction and student characteristics and attitudes, TIMSS 2011 will collect responses to background questionnaires completed by the students tested, their teachers, and their school principals or heads. For countries participating in both TIMSS and PIRLS at the fourth grade there is a special opportunity to collect information from students' parents or caregivers.

## National and Community Contexts

Cultural, social, political, and economic factors provide the context for a country's education system and the mathematics and science curricula. The decisions about educational organization, structure, resources, facilities, teacher qualification, and curriculum are often separate from what actually gets taught. The success a country has in providing effective mathematics and science instruction depends on the value of mathematics and science in the society, the resources available, and the mechanisms it can assemble for providing effective contexts for learning mathematics and science.

## Demographics and Resources

The characteristics of a country's population and the national economy can have a tremendous impact on the relative ease or difficulty of providing effective contexts for learning mathematics and science, and on the availability and extent of the resources required. The sheer size of a country geographically can create difficulties in delivering a uniformly rigorous curriculum, as can a very large population. Having economic resources enables better educational facilities and greater numbers of well-trained teachers and administrators. It also provides the opportunity to invest in education through widespread community programs and by making materials and technology more readily available in classrooms and homes.

Countries with a large and diverse population and few material and human resources generally face greater challenges than those in more favorable circumstances (Bos, Schwippert, & Stubbe, 2007; Gradstein & Schiff, 2004; Kirsch, Braun, Yamamoto, & Sum, 2007; Taylor & Vinjevold, 2000; Trong, 2009). Nationally and locally, the diversity of languages used, levels of adult literacy, and other social and health demographics can influence the difficulty of the educational task. Changing populations due to migration within and across country borders also may affect priorities in education policy and require additional resources.

### Organization and Structure of the Education System

Curriculum development in particular involves consideration of the society that the education system serves. The curriculum reflects the needs and aspirations of the students, the nature and function of learning, and the formulation of statements on what learning is important. In understanding the curriculum students are intended to learn, it is important to know who makes the curricular decisions, what types of decisions are made, and how decisions are communicated to the education community.

How educational policies are established and implemented influences how schools operate and how successful they are in attaining the curricular and educational goals. Some countries have highly centralized systems of education in which most policy-related and curricular decisions are made at the national or regional level, and there is a great deal of uniformity in education in terms of curriculum, textbooks, and general policies. Other countries have much more decentralized systems in which many important decisions are made at the local and school levels, resulting in greater variation in how schools operate and students are taught.

The way students proceed through school (also referred to as “student flow”) is a feature of education systems that varies across countries (Martin, Mullis, & Foy, 2008; Mullis, Martin, & Foy, 2008). Particularly relevant for considering achievement by the fourth year of schooling is the age of entry to formal schooling and the age when formal instruction begins. Due to the complexity of the cognitive demands, students in countries that begin formal schooling at a younger age do not necessarily begin to receive formal instruction in mathematics, and particularly in science, in their first year of schooling. By the eighth year of students’ schooling, in addition to an understanding of promotion and retention policies, it is important to have information about the types of schools students attended at the primary and junior-secondary level, and whether instruction was organized in a tracked or comprehensive program of study. The presence of an examination system with consequences for program placement or grade promotion can have a significant influence on how students learn. Of special interest are recent or planned structural changes in the education system and their effectiveness for improving mathematics and science learning and instruction.

### The Mathematics and Science Curricula

The way the curriculum is documented and how the curriculum implementation is organized at the primary and junior-secondary level has a significant impact on students’ opportunities to learn mathematics and science. Curricular documents define and communicate expectations for students in terms of the knowledge, skills, and attitudes to be developed or acquired through their formal education. The nature and extent of the mathematics and science goals to be attained in school are important to policy makers and curriculum specialists in all countries. Also important is how these goals are kept current in the face of scientific and technological advances, and how the demands and expectations of the society and

the workplace change. As a related issue, curricular documents can include policies about using technology (e.g., calculators, computers, or the Internet) in schools and classrooms.

Although mastery of the subject is a major focus of mathematics and science curricula in most countries, countries differ considerably in how mastery is defined, and how the curriculum specifies that mastery should be achieved. For example, acquiring basic skills, memorizing rules, procedures or facts, understanding mathematical concepts, applying mathematics to “real-life” situations, communicating or reasoning mathematically, and problem solving in every day or novel situations are approaches to teaching mathematics that have been advocated in recent years and are used to varying degrees in different countries. In science, focus on the acquisition of basic science facts, the understanding and application of science concepts, emphasis on formulating a hypothesis, designing and conducting investigations to test hypotheses, and communicating scientific explanations are teaching strategies that are emphasized in some countries more than in others.

At the school level, the relative emphasis and amount of time specified for mathematics, science, and other subjects up through various grade levels can greatly affect the opportunities to learn. Practices such as tracking and streaming can expose students to different curricula. In science, teaching the major components of science as separate subjects can result in different experiences for students compared with the science-as-single-subject approach.

Many countries have systems in place for monitoring and evaluating the implementation of the curriculum and for assessing the status of their education systems. Commonly used methods include national or regional standardized tests, school inspection, and audits. Policy makers also may work collaboratively with the school community (or selected subpopulations) to develop, implement, and

evaluate the curriculum. Also, many countries train teachers in the content and pedagogic approaches specified in the curriculum. Such training may be an integral part of the teacher education curriculum, or it may be included in professional development programs for practicing teachers. The implementation of the curriculum can be further supported through the development and use of teaching materials, including textbooks, instructional guides, and ministerial notes, that are specifically tailored to the curriculum.

## The Schools

The environment and organization of a school influences the ease and effectiveness of the implementation of curricular goals. Accepting that an effective school is not simply a collection of discrete attributes, but rather a well-managed integrated system where each action or policy directly affects all other parts, TIMSS focuses on a set of indicators of school quality that research has shown to characterize schools that are effective and successful in attaining curricular goals.

### School Characteristics

School size, its location, and characteristics of the student body impact how the school system works. There is no clear agreement among researchers and educators about what constitutes a “small” or “large” school. Research has shown that small schools are more intimate learning communities. Small schools tend to provide more safe environments and are characterized by a better sense of community (Hill & Christensen, 2007; Klonsky, 2002; Wasely, Fine, Gladden, Holand, King, Mosak, & Powell, 2000). Schools, however, must be large enough to be cost effective, and provide for a supportive infrastructure such as libraries, laboratories, gymnasia,

but not be so large as to become organizationally cumbersome to run (Martin, Mullis, Gregory, Hoyle, & Shen, 2000).

Schools in economically depressed neighborhoods may provide an environment less conducive to learning than schools in areas well-to-do economically. In some countries schools in urban areas may provide for a more supportive environment because of better staffing conditions and the student population coming from economically more advantaged backgrounds (Erberber, 2009; Johansone, 2009). Also, schools in urban areas may have better access to community resources (museums, libraries, etc.). In contrast, in other countries schools in urban areas are located in neighborhoods with considerable poverty and little community support (Darling-Hammond, 1996).

## School Organization for Instruction

Whether as part of a larger national, regional, or local education system, or because of decisions made at the school level, mathematics and science instruction is carried out within certain organizational constraints. For example, TIMSS found that instructional time, and in particular the time devoted to mathematics and science, can influence achievement. Other school level policies, such as grouping arrangements, may affect achievement indirectly by influencing the social interactions in the classroom and students' motivation to learn (Saleh, Lazonder, & De Jong, 2005).

The school principal plays a critical role in the development of professional learning communities (Louis, Kruse, & Raywid, 1996). Research has shown that the school leadership style has an indirect effect on student achievement (Bruggenkate, 2009). This leadership generally involves a clear articulation of the school's mission and managing curriculum, but can have different dimensions (Davies, 2009; Marzano, Waters, & McNulty, 2005; Robinson, 2007). An

effective school leader brings coherence to the “complexities of schooling” by aligning the structure and culture of the school with its core purpose (DuFour, Ekar, & DuFour, 2005). This includes guiding the school in setting directions and seeking future opportunities, monitoring that the school’s goals are met, as well as building and sustaining an effective learning environment and a positive school climate.

## School Climate for Learning

School climate comprises many factors, including values, cultures, safety practices, and organizational structures that cause a school to function and react in particular ways. Respect for individual students and teachers, a safe and orderly environment, constructive interactions among administrators, teachers, parents, and students all contribute to a positive school climate and lead to higher student achievement (Greenberg, Skidmore, & Rhodes, 2004). For validation purposes, it is important to collect information about school climate as perceived by students, teachers, and principals.

Although a safe and orderly school environment does not in and of itself guarantee high levels of student achievement, student learning can be more difficult in schools where student discipline is a problem, where students are regularly absent or late to class, or where they fear injury or loss of personal property (Osher, Dwyer, & Jimerson, 2006). The sense of security that comes from having few behavior problems and little or no concern about student or teacher safety at school promotes a stable learning environment.

Research has shown that good attendance by students and teachers is related to higher achievement. If students do not attend school regularly, they dramatically reduce their opportunity to learn. Previous TIMSS research has shown that students have lower achievement in schools where principals report attendance problems.

Similarly, teachers' absences have an impact on student achievement by reducing students' opportunities to learn and teachers being absent or leaving school before the end of the school year are an increasing problem (Abadzi, 2007; Clotfelter, Ladd, & Vigdor, 2007; Miller, Murnane, & Willett, 2007). The school environment is also enhanced when staff members show a positive attitude toward students, collaborate in curricular and extracurricular activities, and participate in professional development.

## Teaching Staff

Research attributes much of school leaders' success to the professional development opportunities that they provide for their staff members, particularly teaching staff. The professional development of teachers is of central importance to any attempts to change or reform an education system. Unless teachers participate in ongoing professional development activities, they risk being uninformed about key developments in education and in their subject areas that have occurred since they received their initial training. Effective principals are more creative in finding ways to secure the resources necessary to make professional development opportunities available to their teachers (Cotton, 2003).

The general purpose of teacher evaluation is to safeguard and improve the quality of instruction received by students. There are numerous ways to evaluate teachers. One way found to be effective is principals observing classrooms and providing their teachers feedback about their teaching (Butler, 1997). Other methods used for evaluating teacher quality include teacher peer review and monitoring of student achievement. Successful principals, however, do not only monitor and report student progress data, but also ensure that these are used to improve instruction.

## School Resources

The extent and quality of school resources is also critical for quality instruction (Greenwald, Hedges, & Laine, 1996; Lee & Barro, 2001). These may include resources as basic as trained teachers or adequate classroom space, as well as less essential but beneficial resources like comfortable furniture and surroundings.

Teaching and learning can be facilitated by allocating the facilities, materials, and equipment necessary to achieve the specified learning goals. Results from TIMSS indicate that students in schools that are well resourced generally have higher achievement than those in schools where shortages in resources affect the capacity to implement the curriculum. Two types of resources—general and subject specific—affect the curriculum implementation. General resources include teaching materials, budget for supplies, school buildings, heating/cooling and lighting systems, and classroom space. Subject-specific resources for mathematics and science may include computers, computer software, calculators, laboratory equipment and materials, library materials, and audio-visual resources.

While computers are undoubtedly changing the educational landscape, schools operate with finite resources, and the allocation of money, time, and space for technology may divert scarce resources from other priorities, such as increasing teachers' salaries and professional development, lowering student-teacher ratios, and the provision of teaching resources including laboratory equipment and space. Though research on the effectiveness of technology in the classroom is indeed somewhat inconclusive, there is evidence indicating that computer access and use have a positive impact on student achievement (Laffey, Espinosa, Moore, & Lodree, 2003). The effective use of technology requires suitable training of teachers, students, and school staff. Use of computers can also be enhanced by providing access to the Internet for educational purposes. Factors

limiting computer use include the lack of appropriate software and hardware, software not congruent with the curriculum, lack of teacher training and support, and lack of funding for computer repair and maintenance.

## Parental Involvement

The success of a school can be greatly influenced by a cooperative attitude among school administrators, teachers, and parents (National Education Association, 2008). A significant body of research indicates that when parents participate in their children's education, the result is an increase in students' academic achievement and an improved overall attitude toward school (Dearing, Kreider, & Weiss, 2008). Home-school cooperation, however, requires outreach by the school. Successful schools reach out to their parent communities and provide opportunity and structure for the parents to get involved (Epstein, 2001; Sheldon & Epstein, 2005). Parental involvement may range from volunteering for field trips and fundraising to serving on school committees to revise curricula and actively participating in personnel or school finance decisions. One approach to strengthening the home-school connection is to help parents support children with their mathematics and science schoolwork. Schools may organize training workshops for parents in mathematics and science or offer information sessions on learning strategies and the curriculum.

## Classroom Contexts

The teacher is the primary agent of curriculum implementation and a very influential determinant of the classroom environment (Lundberg & Linnakyla, 1993; Rivkin, Hanushek, & Kain, 2005). Teachers vary in their preparation and training, teaching experience, attitudes, and use of particular instructional approaches. Also, the behaviors, attitudes, and preparedness of the students in the

classroom may influence the teacher's instructional choices, thereby affecting student learning (Kurtz-Costes & Schneider, 1994).

Even though the curricular policies and resources of the school often set the tone for accomplishments in the classroom, and the school provides a general context for learning, students' day-to-day classroom activities are likely to have a more direct impact on their mathematics and science achievement. The instructional approaches and materials used are clearly important for establishing teaching and learning patterns in the classroom, including the curriculum topics that are actually addressed, the strategies employed to teach these, and the availability of resources, such as computers or laboratory equipment.

### Teacher Education and Development

Research suggests that to ensure excellence teachers should have high academic skills, teach in the field in which they received their training, have more than a few years of experience, and participate in high-quality induction and professional development programs (Mayer, Mullens, & Moore, 2000). The qualification and competence of teachers can be critical, and prospective teachers need coursework for knowledge and understanding, experience from practical training in schools, and a good induction process.

TIMSS has shown that there is considerable variation across countries in the level of education teachers complete as well as in the percentage of students taught mathematics or science by teachers with a major in the subject. Research has shown that teachers who have subject specific academic degrees are generally more successful than teachers teaching "out of field" (Goldhaber & Brewer, 2000). In the 21st century, it is even more important than ever for a teacher to have extensive content and curriculum knowledge as well as pedagogical knowledge, knowledge about learners and their characteristics, and

knowledge about information technology (Darling-Hammond, 2006; Ertmer, 2003; Hill & Lubienski, 2007).

The extent of teachers' continuing education and exposure to recent developments within the field of teaching mathematics and science is also important. Professional development through seminars, workshops, conferences, and professional journals can help teachers to increase their effectiveness and broaden their knowledge (Yoon, Duncan, Lee, Scarloss, & Shapley, 2007). In some countries and jurisdictions, teachers are required to participate in such activities. Moreover, it has been suggested that the profession of teaching is one that requires lifelong learning, and that the most effective teachers continue to acquire new knowledge and skills throughout their careers.

The transition from university to a school teaching position can be difficult. Consequently, in many countries a large percentage of new teachers leave the profession after only a few years of teaching (Tillmann, 2005; Moskowitz & Stephens, 1997). The extent to which schools take an active role in the acculturation and transition of the new teacher may be important for maintaining a stable teaching force. Mentoring programs, modeling of good teacher practice by peers, and induction programs designed by experienced teachers within the school may be important aids to the beginning teacher.

## Teacher Characteristics

Some literature examines the influence of teacher gender, age, and experience on student achievement. Studies have suggested that students learn more when taught by experienced teachers than they do when taught by teachers with just a few years experience. However, the relationship between experience and achievement may be affected by many factors. For example, assignment policies within schools may result in the more highly skilled teachers

getting specialized classes, or older teachers getting higher-track classes. The need for long serving teachers to engage in professional development, and the extent to which they do so, can also impact their effectiveness. Controlling for other factors, teaching experience is found to make a difference, particularly in the early years of teaching (Clotfelter, Ladd, & Vigdor, 2006; Hanushek, Kain, O'Brien, & Rivkin, 2005). Findings about the differential impact of male and female teachers also vary by many factors, such as the students' gender, ethnic background, or socioeconomic status (Dee, 2006; UNESCO, 2006).

Teacher attitudes, such as motivation and self-efficacy, shape their students' learning experiences and academic achievement. Teachers who are satisfied with their profession and the working conditions at their school are more motivated to teach and prepare their instruction. Dissatisfying factors may be low salaries, too many teaching hours, lack of equipment and workspace, and lack of communication and collaboration among teaching staff. Collaboration among teachers is widely considered critical for creating and maintaining schools as professional learning communities, where instructional ideas and innovations are shared. Research suggests that if teachers work together to become more collaborative and work oriented, student learning can be increased (Wheelan & Kesselring, 2005). Teachers that discuss their work with colleagues and collaborate in planning and implementing lessons usually feel less isolated and are less likely to leave teaching (Johnson, Berg, & Donaldson, 2005).

Teachers' self-efficacy refers to their sense of personal ability to organize and execute their teaching. Teachers with high beliefs in their abilities are more open to new ideas and less likely to experience emotional burnout. Research has shown that teachers' self-confidence in their teaching skills is not only associated with their professional behavior, but also with students' performance and motivation (Bandura, 1997; Henson, 2002).

## Classroom Characteristics

Because most of the teaching and learning in school take place in the classroom, instructional activities often are influenced by the classroom environment. The fundamental characteristics of the classroom include class size, instructional time, and class composition.

Some research indicates that smaller class sizes during the early years of schooling may benefit students' academic development. Smaller classes may be the result of a variety of government policies that cap class size. For example, class size reduction may reflect selective resource allocation to special needs or practical classes. Because of these different reasons for policies on class size, research findings are somewhat ambiguous (Nye, Hedges, & Konstantopoulos, 2001). Whatever the reason for the class size, there is little doubt that it shapes the classroom environment and affects how teachers implement the instruction.

Results from TIMSS show that there is variation between countries in the intended instructional time prescribed in the curriculum and the time implemented in the classroom. On average, however, there was very close agreement between the curriculum guidelines and teachers' reports about the implementation. Research for developing countries has shown that it is especially important that instructional time is used effectively toward the learning goals and not wasted for secondary activities not related to instructional content (Abadzi, 2007).

The students themselves can be very important to the classroom atmosphere. Because prior knowledge guides learning, students need the prerequisites before they can make gains in mathematics and science achievement. Effective teachers assess students' language skills and conceptual understanding, and link new ideas, skills, and competencies to prior understandings. Students with some

physical or psychological barrier, such as lack of nutrition or sleep deprivation, are not able to attend and participate as well in the moment of instruction. A classroom full of alert, well-fed students will be more ready to learn than tired and hungry students or students with unaddressed disabilities (McLaughlin, McGrath, Burian-Fitzgerald, Lanahan, Scotchmer, Enyeart, & Salganik, 2005).

### Instructional Materials and Technology

Another aspect of the classroom that is relevant for successful implementation of the intended curriculum is the availability and use of technology and other instructional materials experienced by students in schools. Computers and the Internet provide students ways to explore concepts in-depth, trigger enthusiasm and motivation for learning, enable students to learn at their own pace, and provide students with access to vast information sources. Besides giving students access to the Internet, computers can serve a number of other educational purposes. While initially limited to learning drills and practice, they are now used in a variety of ways including tutorials, simulations, games, and applications. New software enables students to pose their own problems and explore and discover mathematics and scientific properties on their own. Computer software for modeling and visualization of ideas can open a whole new world to students and help them connect these ideas to their language and symbol systems. For computers to be integrated effectively into instruction, teachers have to feel comfortable to use them and receive adequate technical and pedagogical support.

Calculator use varies widely among, and even within countries, but generally is increasing steadily as cost becomes less of an impediment and mathematics curricula evolve to take calculators into account. Many countries have policies regulating the access to and use of calculators, especially at the earlier grade levels. What

those policies are and how they change over the grades can be important in understanding the curriculum. Calculators can be used in exploring number recognition, counting, and the concepts of larger and smaller. They can allow students to solve numerical problems faster by eliminating tedious computation and thus become more involved in the learning process. How best to make use of calculators, and what role they should have, continue to be questions of importance to mathematics curriculum specialists and teachers.

In addition to textbooks or workbooks, resources used in mathematics instruction include tools or visual representations of mathematical objects that help students understand quantities and procedures. Research has explored the different ways these objects can be used to facilitate learning basic mathematical skills and solving mathematical problems (Manalo, Bunnell, & Stillman, 2000; Witzel, Mercer, & Miller, 2003).

### Curriculum Topics Taught

A major focus of the implemented curriculum is the extent to which the mathematics and science topics in the TIMSS frameworks are covered in the classroom. TIMSS addresses this question by asking the mathematics and science teachers of the students assessed to indicate whether each of the topics tested has been covered in class, either in the current or previous years, and the percentage of time in class devoted to each of the TIMSS mathematics and science content domains. TIMSS characterizes the coverage and level of rigor of the mathematics and science courses taught in participating countries by describing the main focus of the work in the classes being tested.

### Instructional Activities

Teachers employ a variety of strategies to encourage students to learn. Students learn best when they are interested and involved.

Major instructional practices that increase motivation include setting goals, bringing interesting materials to class, relating what students are learning to their daily lives, and providing extrinsic rewards and praise. To move students from extrinsic to intrinsic motivation teachers can express genuine care for their students' cognitive, emotional, and physical needs, give students knowledge-building experiences, and increase their self-esteem and self-efficacy in mathematics and science by asking them to solve problems and explain their answers (Pintrich, 2003). For example, studies have shown students who conduct hands-on learning activities outperform their peers as do students who have the benefit of individualized instruction (Wenglinsky, 2000). In science, research has shown higher achievement for eighth grade students to be associated with increased frequency of doing hands-on activities in science, student discussion of measurements and results from hands-on activities, and students working with others on a science activity or project as well as with increased frequency of reading textbooks and writing longer answers about science (Braun, Coley, Jia, & Trapani, 2009).

Reports on how much emphasis is placed on integrating technology into different aspects of instruction also provide important information about classroom experiences. As discussed earlier, use of the Internet and computer software can expand students' learning opportunities. Also, calculators are becoming more widely used in many countries.

Homework is a way to extend instruction and assess student progress. The amount of homework assigned for mathematics and science varies both within and across countries. In some countries, homework is assigned typically to students who need it the most. In other countries, students receive homework as enrichment exercise. For this reason research on the effectiveness of homework shows mixed results (Cooper, Robinson, & Patall, 2006; Trautwein, 2007).

## Assessment

In addition to homework, teachers have a number of ways to monitor student progress and achievement. TIMSS results show that teachers devote a fair amount of time to student assessment, whether as a means of gauging what students have learned to guide future learning, or for providing feedback to students, teachers, and parents. The frequency and format of assessment are important indicators of teaching and school pedagogy. Informal assessments during instruction help teachers identify the needs of particular individuals, evaluate the pace of the presentation, and adapt the instruction. Formal tests, both teacher-made and standardized assessments, typically are used to make important decisions about the students, such as grades or marks, or about schools for accountability purposes. Teachers use a variety of formats and test a wide range of content and cognitive skills. The types of questions included in tests and quizzes can send strong signals to students about what is important.

## Student Characteristics and Attitudes

Students bring experiences and expectations to the classroom that affect their learning aptitude and motivation. Schools' and teachers' success in implementing the curriculum is influenced by students' prerequisite knowledge and skills as well as their attitudes toward learning mathematics and science.

## Student Demographics and Home Background

Students come to school from different backgrounds and with different experiences. There is ample evidence that student achievement in mathematics and science is related to student characteristics (e.g., gender, language spoken) and home background factors (e.g., immigration status, socioeconomic background).

While for decades there has been a concern about girls lagging behind in mathematics and science, currently the majority of research shows the achievement difference between boys and girls in mathematics and science to be minimal and smaller than the difference associated with home background factors (Coley, 2001; McGraw, Lubienski, & Strutchens, 2006). TIMSS has shown that there is no large overall difference in average mathematics and science achievement between boys and girls across participating countries, on average, although the situation varies from country to country. In contrast, TIMSS has shown a learning gap between students who do and do not have the language of instruction as their primary language.

In many countries, increasing migration has resulted in a significant population with immigrant backgrounds whose native language is not the language of instruction. Immigrant students often encounter difficulties as they adjust to a new environment and culture and receive instruction that is different from the language spoken at home (Lolock, 2001; Schmid, 2001). In some countries, immigrant students are at a double disadvantage due to their parents' education and socioeconomic background.

Research consistently shows a strong positive relationship between achievement and indicators of socio-economic status, such as parents' or caregivers' level of education or occupation class (Bradley & Corwyn, 2002; Haveman & Wolfe, 2008; Willms, 2006). Other home background factors that have also been shown to be important include the number of books in the home, the presence of a study desk, and the availability of a computer and an Internet connection (National Center for Education Statistics, 2006; Woessmann, 2004). Such factors are also indicative of the home support for learning and may influence students' overall educational aspirations.

Social capital theory argues that a strong home-school connection is indicative of students' educational success. That is because "better connected" families can provide more effective support to their children and help with their schoolwork. Social resources have been found to have a positive impact on student achievement, though the effectiveness of parental support for schoolwork is somewhat ambiguous (Marks, Cresswell, & Ainley, 2006; Lee & Bowen, 2006). Parents may be more likely to help with schoolwork when they are able to and are interested in engaging with the content, aside from their children's marks or grades. At the same time, parents may only help when their child is struggling and in need of academic support.

Students' experiences before school starts are pertinent to their later success. Small children engage in more or less structured early numeracy activities in their homes and pre-school which stimulate their interest and enhance the development of their abilities (Melhuish, Phan, Sylva, Sammons, Siraj-Blatchford, & Taggart, 2008; Sarama & Clements, 2009). These activities include playing with blocks or construction toys, reciting counting rhymes or singing counting songs, playing games involving shapes, and playing other types of games that involve quantitative reasoning. Young children's mathematical skills vary significantly across countries and are strongly related to their family's socioeconomic background (Clements & Sarama, 2009; West, Denton, & Germino-Hausken, 2000).

## Student Attitudes Toward Learning Mathematics and Science

Helping students to develop positive attitudes toward mathematics and science is an important goal of the curriculum in many countries. Students' motivation to learn can be affected by whether they find the subject enjoyable, place value on the subject, and think it is

important in the present and for future careers. Personal interest in a subject motivates the learner and facilitates the learning in going beyond surface level information. In addition, students' motivation can be affected by their self confidence in learning the subject. TIMSS results have shown that students with more self-efficacy or higher self-esteem typically perform better in mathematics and science. Because motivation to learn includes having a feeling that you can succeed, it is important for students to have a strong self-concept about their abilities in order to continue building on current levels of learning to move to higher plateaus. A positive attitude toward mathematics and science and a strong self-concept encourage students to engage with the instruction and show persistence, effort, and attentiveness. Students showing high levels of engagement typically perform higher and high achievers, again, have a strong self-concept and positive attitude (Akey, 2006; Singh, Granville, & Dika, 2002).

Like the amount of homework assigned by the teacher, the time students spend on homework assignments varies across countries and the relationship with achievement is somewhat ambiguous. Higher achieving students may be more motivated to spend time on homework. Lower achieving students, however, may take longer to complete their tasks. There are indications that it is not the amount of time spent on homework per se, but the degree of conscientiousness and motivation to complete the homework assignments and the homework quality that matters. The diligence put into homework and how well it turns out may be stronger predictors of academic success than the time spent on it (Trautwein, Luedtke, Kastens, & Koeller, 2006).