

## Overview

Learning takes place within a context, and not in isolation. There are numerous contextual factors that effect 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 students learning in mathematics and science, it is important to understand the contexts in which students learn. TIMSS in every cycle collects a range of information about these contexts for learning, together with assessing students' performance in mathematics and science. The TIMSS 2007 Contextual Framework encompasses five broad areas on which information is collected:

- Curriculum
- Schools
- Teachers and Their Preparation
- Classroom Activities and Characteristics
- Students

In particular, TIMSS examines the curricular goals of the education system and how the system is organized to attain those goals; the educational resources and facilities provided; the teaching force and how it is educated, equipped, and supported; classroom activities and characteristics; home support and involvement; and the knowledge and attitudes that students and teachers themselves bring to the educational enterprise. 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.

## The Curriculum

Building on IEA's experience and past TIMSS studies, the TIMSS 2007 contextual framework addresses five broad aspects of the intended curriculum in mathematics and science, from its formulation to its implementation.

### FORMULATING THE CURRICULUM

Curriculum development involves consideration of the society which 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 intended curriculum, 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.

### SCOPE AND CONTENT OF THE CURRICULUM

Curricular documents define and communicate expectations for students in terms of the knowledge, skills, and attitudes to be acquired or developed 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 society and the workplace change. As a related issue, curricular documents can include policies about using technology (e.g., calculators, computers, and the internet) in the 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 the curriculum specifies that mastery should be achieved. For example, acquiring basic skills, understanding mathematical concepts and principles, applying mathematics to “real-life” situations, communicating mathematically, reasoning mathematically and problem solving in novel situations are approaches to teaching mathematics that have been advocated in recent years and are used to varying degrees in

different countries.<sup>1</sup> 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 a hypothesis, and communicating scientific explanations are teaching strategies that are emphasized in some countries more than in others.<sup>2</sup>

## ORGANIZATION OF THE CURRICULUM

The way the education system – national, regional, and local – is organized has a significant impact on students’ opportunities to learn mathematics and science. At the school level, the relative emphasis on and amount of time specified for mathematics, science, and other subjects up through various grade levels can greatly affect such opportunities. Practices such as tracking, streaming, and setting 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.

## MONITORING AND EVALUATING THE IMPLEMENTED CURRICULUM

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 standardized tests, school inspection, and audits. Policy makers may use influences external to the school, for example national or regional standardized tests, to prescribe the implementation of the curriculum. Policy makers also may work collaboratively with the school community (or selected subpopulations) to develop, implement, and evaluate the curriculum.

## CURRICULAR MATERIALS AND SUPPORT

Apart from the use of standardized tests, inspections, and audits, countries can employ a range of other strategies to facilitate the implementation of the intended curriculum. These include training teachers in

1 Mullis, I.V.S., Martin, M.O., Gonzalez, E.J., and Chrostowski, S.J., (2004). *TIMSS 2003 international mathematics report: Findings from IEA's trends in international mathematics and science study at the fourth and eighth grades*, Chestnut Hill, MA: Boston College.

2 Martin, M.O., Mullis, I.V.S., Gonzalez, E.J., and Chrostowski, S.J., (2004). *TIMSS 2003 international science report: Findings from IEA's trends in international mathematics and science study at the fourth and eighth grades*, Chestnut Hill, MA: Boston College.

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. 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

In the TIMSS 2007 contextual model, the school is the institution through which the goals of the curriculum are implemented. Accepting that a high quality 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 such schools.

### SCHOOL DEMOGRAPHICS

School size, its location, and characteristics of its student body impact how the school system works. There is no clear agreement among researchers and educators about what constitutes a “small” school or a “large” school. Schools must be large enough so that the necessary investment in libraries, laboratories, gymnasias, and the like is economically sound but not so large as to be organizationally cumbersome to run.<sup>3</sup> Research has shown that students in small schools are involved in a greater variety of activities and derive more satisfaction from their participation than students in large schools. Interpersonal relations between and among students, teachers, and administrators are more positive in small schools than in large ones.<sup>4</sup>

It is also important to know about the composition of a school’s student body. Frequent turnovers of the student body can affect continuity of instruction and can disrupt student learning. Schools with a large number of students coming from economically disadvantaged families generally have lower student achievement because of less

3 Martin, M.O., Mullis, I.V.S., Gregory, K.D., Hoyle, C., and Shen, C. (2000). *Effective schools in science and mathematics*, Chestnut Hill, MA: Boston College.

4 Bates, J. T. (1993). *Portrait of a successful rural alternative school*. *Rural Educator*, 14(3), 20-24.

supportive home environments, difficulty in recruiting and retaining good teachers in the school, fewer resources and more student behavior problems.

### SCHOOL ORGANIZATION

Whether as part of a larger national, regional, or local education system or because of decisions made at the school level, science and mathematics instruction is carried out within certain organizational constraints. For example, the time in terms of days per year and minutes per day allotted for schooling, and in particular for mathematics and science instruction, can influence achievement. It is also important to know about different types of schools, since some schools may specialize. For example, in countries with tracking, the school may be designated to emphasize either an academic or a vocational curriculum.

### SCHOOL GOALS

Research on effective schools suggests that successful schools identify and communicate ambitious but reasonable goals and work toward implementing them. Commonly articulated school goals include basic literacy, academic excellence, personal growth, human relation skills, good work habits, and self-discipline.<sup>5</sup>

### ROLES OF THE SCHOOL PRINCIPAL

Research shows that achievement improves in schools where principals are effective instructional leaders.<sup>6</sup> The school principal typically fulfills multiple leadership roles. These include ensuring that the school, its operation, and its resources are managed optimally. The principal may guide the school in setting directions, seeking future opportunities, and building and sustaining a learning environment. He or she can facilitate the development, articulation, implementation, stewardship, and evaluation of a model of learning that is shared and supported by the school community. The principal may actively advocate, nurture, and sustain a positive school culture and an education program conducive

5 Henke, R.R., Choy, S.P., Geis, S. and Broughmann, S.P. (1996). *Schools and staffing in the united states: A statistical profile, 1993-94(NCES 96-124)*. US Department of Education, National Center for Education Statistics. Washington, DC: US Government Printing Office.

6 DuFour, R. (1999). *Help wanted: Principals who can lead learning communities*. NASSP Bulletin, 12-17.

to student learning and teachers' professional growth. The primary roles that the principal fulfills provide a useful indication of the administrative and educational structure of the school.

### RESOURCES TO SUPPORT MATHEMATICS AND SCIENCE LEARNING

Curriculum implementation 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 capacity to implement the curriculum. Two types of resources affect implementation of the curriculum. General resources include teaching materials, budget for supplies, school buildings and supplies, 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.

### TECHNOLOGY, SUPPORT, AND EQUIPMENT

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 teacher salaries, teachers' professional development, lowering student-teacher ratios, and the provision of teaching resources including laboratory equipment and space. Further, the sustainability of school computer systems, and the continuity of support staffing may be as important as the acquisition of the computers.

The effective and efficient use of computers 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.

## SCHOOL SOCIAL CLIMATE

A school's social climate comprises the values, cultures, safety practices, and organizational structures that cause it 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. A supportive school climate helps to build better morale among teachers and students and that leads to higher student achievement. 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. For validation purposes, it is important to collect information about school climate as perceived by teachers, students, and principals. School-wide programs that provide for the basic needs of students and their families (e.g., Lunches for students, after-school child care, or adult literacy programs) may also be important.

## PARENTAL INVOLVEMENT

A significant body of research indicates that when parents participate in their children's education, the result is an increase in student achievement and an improvement of students' attitudes. Increased attendance, fewer discipline problems, and higher aspirations also have been correlated with an increase in parent involvement.<sup>7</sup> Effective schools reach out to their parent communities and provide structure for the parents to be involved in their children's school. Parental involvement can be in the areas of checking homework, volunteering for field trips, and fund raising. Parents also can get involved in the decision-making or administrative processes of the school (e.g., selecting school personnel, reviewing or making decision for school finances, etc.).

## TEACHER RECRUITMENT

The growth of technology in recent years has meant that education systems must compete with industry for the best mathematics and

7 Henderson, A. T., & Berla, N. (1994). *A new generation of evidence: The family is critical to student achievement*. St. Louis, MO: Danforth Foundation and Flint, MI: Mott (C. S.) Foundation.

science candidates. The rapid advancement of mathematics and science necessitates that prospective teachers be capable of keeping pace with these fast-evolving fields. This calls for the attraction of top-level applicants who are capable of adjusting their teaching to the evolving demands of modern education. Employment contracts, incentives such as free college education, attractive pay, housing facility, and giving bonuses to deserving teachers are some of the methods used to recruit suitable candidates.

### TEACHER EVALUATION

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 is observation of their teaching by the principal, inspectors or senior member of the staff. Some of other methods that can be used for evaluating teachers quality are student achievement and teacher peer review. Schools can use anyone of them or combination of these ways. However, to improve and enhance classroom instructional practices schools must also provide a process that allows and encourages supervisors and teachers to work together.

### Teachers and Their Preparation

Teachers are the primary agents of curriculum implementation. Regardless of how closely prescribed the curriculum, or how explicit the textbook, it is the actions of the teacher in the classroom that most affect student learning. What teachers know and are able to do is of critical importance. A recent review 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.<sup>8</sup>

### ACADEMIC PREPARATION AND CERTIFICATION

Aware of the key role played by the teacher in implementing the curriculum, many countries are focusing on improving education for

<sup>8</sup> Mayer, D.P., Mullens, J.E., and Moore, M.T. (2000). *Monitoring school quality: An indicators report, NCES 2001-030*, Washington, DC: National Center for Education Statistics.



aspiring teachers, particularly the mathematics and science prerequisites necessary for effective teaching in these subject areas.

The authority or organization responsible for granting certification for teachers and the methods of certification to teach vary widely across countries. The methods might include the completing of specified courses, passing exams, supervised practical experience, obtaining a university degree, serving a probation period, and completion of an induction program. In some countries there may be alternative methods of being certified, especially in subject areas with a shortage of teachers.

The relative emphasis on content knowledge and pedagogic approach of trainee teachers, and how teacher education programs keep abreast of the changes brought about by rapid advances in science and technology, are important features of teacher preparation programs. They employ different teaching methods to prepare teachers to teach their subject matter and to enable them to become broadly educated, reflective, professional educators. Developing a lifelong positive attitude toward learning also may be an important facet of teacher education. Collaboration between universities and schools and the use of teacher competency standards may further contribute to good academic preparation. In many countries future teachers are prepared to teach the intended curriculum as part of both pre- and in-service training.

### TEACHER ASSIGNMENT

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. While there can be both problems and benefits associated with teachers teaching “out of field,” of interest is how such teachers acquire the subject-specific knowledge they need in order to teach effectively.

## TEACHER INDUCTION

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.<sup>9</sup> The extent to which schools take an active role in the acculturation and transition of the new teacher may be important. Mentoring, the modeling of good teacher practice by peers, and induction programs designed by experienced teachers within the school may be important to aid the beginning teacher.

## PROFESSIONAL DEVELOPMENT

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.

Focus on academic subject matter, opportunities for active learning (observing and being observed teaching, planning for classroom implementation, reviewing student work, giving a lecture or presentation, writing a lesson plan), and coherence with other learning activities going on in the daily life of the school are important features of successful teacher professional development activities.<sup>10</sup> There is special concern that without access to high-quality professional development, teachers will be unable to benefit from the advances made in information technology.

## 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

9 Moskowitz, J. and Stephens, M., eds. (1997). *From students of teaching to teachers of students: Teacher induction around the pacific rim*, Washington, DC: U.S. Department of Education.

10 Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., Yoon, K. S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal*, 38(4), 915-945.

result in the more highly skilled teachers getting specific classes, or older teachers getting higher-tracked 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.

## **Classroom Activities and Characteristics**

Although the school provides the general context for learning, it is in the classroom setting and through the guidance of the teacher that most teaching and learning take place. The classroom setting here is taken to include work assigned in the classroom but completed elsewhere, such as homework, library assignments, or field work. Aspects of the implemented curriculum that are most readily studied in the classroom include the curriculum topics that are actually addressed, the pedagogic approaches used, the materials and equipment available, and the conditions under which learning takes place, including the size and composition of the class and the amount of classroom time devoted to mathematics and science education.

### **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.

### **CLASS SIZE**

Class size can serve as an economic indicator, with smaller classes signifying greater wealth. However, smaller class sizes may be the result of government policies that cap class size. Further, class size may reflect

selective resource allocation to, for example, special needs or practical classes. Whatever the reason for the class size, there is little doubt that it affects how teachers implement the curriculum.

### INSTRUCTIONAL TIME

The amount of classroom instructional time devoted to mathematics and science is an important aspect of curricular implementation. TIMSS has shown that the efficient use of that time and the disruptive effects of outside interruptions are aspects related to effective teaching.

### INSTRUCTIONAL ACTIVITIES

Teachers employ a variety of strategies to encourage students to learn. Some of these methods are more effective than others in contributing to student achievement. Information on how teachers allot their time to such activities as lecture-style presentation, teacher-guided student practice, re-teaching and clarifying content and procedures, small group work, and independent practice, for example, provides useful evidence about the predominant pedagogic approaches in the classroom. Student reports of how much time they spend being shown how to do mathematics and science, working from worksheets or textbooks, working on projects on their own or in small groups, or discussing homework also provide important information about classroom activities. 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.<sup>11</sup>

### ASSESSMENT AND HOMEWORK

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.

Homework is a way to extend instruction and assess student progress. It serves to increase the time devoted to a subject. The reasons

<sup>11</sup> Wenglinsky, H. (2000). *How teaching matters: Bringing the classroom back into discussions of teacher quality*. Educational Testing Service, Princeton, NJ. Policy Information Center.

for assigning homework as well as the amount and types assigned are important pedagogic considerations. It can be used to reinforce and/or extend the concepts developed in a lesson.

### COMPUTER AND INTERNET USE

The computer is rapidly transforming education as students prepare to enter the technological workforce. Computers and the internet provide students new ways to explore concepts at a depth that has not been possible in the past. These technological tools can trigger a new enthusiasm and motivation for learning, enable students to learn at their own pace, and provide students with access to vast information sources.

There is evidence to show that multiple layers of access to the internet, for example at schools, in libraries, and at home, is important. For countries in which students do have ready access to the internet, it is important that they be taught how to use the information, and how to evaluate its truth or worth.

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.

### CALCULATOR USE

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.

### EMPHASIS ON INVESTIGATIONS

The emphasis on conducting projects and investigations varies widely across countries. An exploration of the frequency and the nature of a task can illuminate the learning at issue. In science, practical investigations often are an integral part of the learning process. The extent to which these activities are demonstrated by the teacher and conducted by the students also shows variation across countries.

## The Students

### HOME BACKGROUND

Students come to school from different backgrounds and with different experiences. The number of books in the home, availability of a study desk, the presence of a computer, the educational level of the parents, and the extent to which students speak the language of instruction have been shown to be important home background variables, indicative of the family's socio-economic status, that are related to academic achievement. Such factors are also indicative of the home support for learning and can influence students' overall educational aspirations. The extent to which employment, sports and recreational pastimes, and other activities occupy the student's time may also affect learning.

### ATTITUDES

Creating a positive attitude in students 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 career aspirations. In addition, students' motivation can be affected by their self confidence in learning the subject.