CHAPTER 3

TIMSS 2023 Context Questionnaire Framework

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Overview

In addition to measuring trends in students' mathematics and science achievement, TIMSS collects important information about contexts for student learning. Educational research, including previous cycles of TIMSS, has long demonstrated substantive relationships among learning environments and student achievement across countries. Students with more opportunities to learn and more supportive learning environments consistently have higher mathematics and science achievement than those who do not. While the indicators and components of these factors may shift (particularly with the ongoing introduction of new technological tools and approaches for digital learning), these relationships have remained stable over time.

Previous cycles of the TIMSS assessment have provided high-quality measures of mathematics and science achievement for fourth and eighth grade students, as well as extensive information about those students' in- and out-of-school experiences. These data are an important resource for research on improving mathematics and science education. TIMSS 2023 builds upon this foundation, collecting information that allows for measurement of contextual factors that have remained relevant over time, while also addressing new areas of research and policy relevance.

The *TIMSS 2023 Context Questionnaire Framework* outlines the information to be collected in the TIMSS 2023 Questionnaires with brief rationales and selected references. It begins with an overview of the questionnaires and a brief summary of their development process. A discussion of the analytic approach employed in the construction of scales for TIMSS 2023 follows this introduction. Similar to previous TIMSS cycles, the bulk of the framework is organized by five areas of influence on students' mathematics and science achievement: home contexts, school contexts, classroom contexts, student attributes, and national contexts.

The Data Collection Instruments

TIMSS 2023 includes four context questionnaires with the fourth grade assessment, and three with the eighth grade assessment. Each is described below:

- The Home Questionnaire, entitled the Early Learning Survey, is completed by the parents or primary caregivers of fourth grade students participating in TIMSS 2023. This questionnaire

collects information about students' home contexts, including participation in early childhood education, early literacy and numeracy activities, language(s) spoken at home, and parents'/guardians' educational and professional backgrounds. The questionnaire requires about 20 minutes to complete.

- The School Questionnaire is completed by the principal of each participating school sampled for TIMSS 2023. This questionnaire collects information about school characteristics, including student demographics and school resources. The questionnaire requires about 30 minutes to complete and is administered as a part of TIMSS 2023 for both the fourth and eighth grades.
- The Teacher Questionnaire is completed by students' mathematics and science teachers. This is typically one classroom teacher for fourth grade students and separate mathematics and science teachers for eighth grade students. This questionnaire asks about classroom contexts, such as instructional approaches and integration of technology, as well as teacher characteristics, including teacher preparation, career satisfaction, and professional development. The questionnaire takes about 35 minutes to complete.
- The Student Questionnaire is completed by all fourth and eighth grade students participating in TIMSS 2023 following the mathematics and science assessment. This questionnaire collects information about students' home environment, such as resources for learning, as well as students' experiences in school (e.g., sense of school belonging, bullying) and attitudes towards mathematics and science. The questionnaire takes up to 30 minutes to complete. Two versions of this questionnaire are provided at the eighth grade: one for students who take science as an integrated subject and one for students enrolled in separate science subjects (biology, chemistry, physics, and earth science).

In addition to the four questionnaires described above, TIMSS 2023 collects information about national contexts shaping mathematics and science education. As with previous cycles of TIMSS, representatives from each country provide information for the *TIMSS 2023 Encyclopedia*. This includes the completion of a curriculum questionnaire about mathematics and science education policies and curricula, as well as contribution of a country-specific encyclopedia chapter providing additional qualitative information about these topics.

The Development Process

The TIMSS questionnaires focus on policy relevant and potentially malleable attributes of students' learning contexts that can aid interpretation of mathematics and science achievement across and within countries.

The TIMSS and PIRLS International Study Center works with the TIMSS 2023 Questionnaire Item Review Committee (QIRC) and National Research Coordinators (NRCs) to update the context questionnaire framework and questionnaires for each successive TIMSS assessment. This includes adding new topics, refining measurement of existing topics, and deleting topics that are no longer useful. Development for TIMSS 2023 began in January 2021, when staff at the TIMSS and PIRLS International

Study Center drafted an updated context questionnaire framework and suggested revisions for each of the questionnaires. The TIMSS 2023 QIRC reviewed the updated framework at its first meeting in March 2021. This was followed by an online asynchronous review by NRCs prior to publication. The questionnaire instruments were reviewed at the second QIRC meeting in August 2021, as well as by the NRCs prior to field testing. Following the field test, the QIRC and NRCs reviewed and finalized the questionnaires in 2022 for the TIMSS 2023 data collection.

The Analytic Approach

Since 2011, TIMSS has used item response theory methods to develop background scales measuring constructs that are related to students' mathematics and science achievement.[1] These scales summarize select questionnaire data more reliably than the responses to individual questions and enhance the interpretability of relationships with achievement. All four of the TIMSS 2023 questionnaires (Home, School, Teacher, and Student) include several scales. Through each assessment cycle, work continues on improving the content and measurement properties of the context questionnaire scales. For TIMSS 2023, this includes evaluating measurement invariance of the context scales across countries, use of the generalized partial credit model[2] for scale calibration, and exploring more complex types of reporting to better capture the interrelatedness of unidimensional constructs measured in individual scales. Constructs that TIMSS 2023 intends to measure utilizing scales are noted throughout the remainder of this framework, along with the names of the intended scales.

Home Contexts

Home Environment Support

Home Resources

Parents' or guardians' socioeconomic status has long had consistent relationships with students' academic achievement.[3,4,5] This pattern holds across both developed and developing countries, and socioeconomic academic achievement gaps have grown within the past few decades.[6,7] Socioeconomic status is often indicated through proxy variables, including parental level of education and occupation. TIMSS expands this classic definition by also collecting information about various resources for learning that are available in the home, such as the number of books, a quiet place to do schoolwork, and access to the internet and various digital devices.

For fourth grade students, TIMSS collects and summarizes information about home resources through the *Home Resources for Learning* scale, which is created from items in the Home and Student Questionnaires. The eighth grade counterpart is the *Home Educational Resources* scale, which is created from items in the Student Questionnaire.

Language(s) Spoken at Home

Internationally, there are many reasons why children might speak a different language at home than they do in school. Some countries have numerous national languages, and immigrant families may be unfamiliar with a given national language. Some parents may also prize multilingualism and deliberately

expose their children to more than one language at home. Learning mathematics or science in a language other than that which is primarily spoken at home can pose difficulties for students because they are learning both curricular concepts and a less familiar or unfamiliar language.[8,9]

For fourth grade students, TIMSS collects information about the language(s) spoken in the home through both the Home and Student Questionnaires. For eighth grade students, this information is collected through the Student Questionnaire.

Expectations for Further Education

Parents and guardians have expectations for their children's educational attainment. These adults can play a key role in setting educational goals for their children, as well as in teaching their children about the value of education.[10,11] Research has shown positive relationships between these expectations and academic achievement at various levels of schooling.[12,13,14]

TIMSS collects information about parent/guardian expectations for their children's education through the Home Questionnaire. Parents are asked to indicate the level of education they expect their child to attain. Eighth grade students are asked to indicate the level of education they expect themselves to attain in the Student Questionnaire.

Early Learning Experiences

Early Literacy and Numeracy Activities

Considerable research has documented the importance of early childhood learning activities and their relationships with student achievement and other education outcomes.[15,16,17,18] Early numeracy activities at home may influence later mathematics performance not only directly, but also through the enhancing students' mathematics self-efficacy.[19] Engaging children in early numeracy activities can also stimulate their interest in mathematics and enhance development of numeracy skills.[20,21] Past analyses of TIMSS and PIRLS data have shown that both early numeracy and literacy activities are related to children's fourth grade achievement in mathematics, science, and reading.[22] The association between mathematics and science achievement and literacy skills may be attributable to the fact that students' understanding of mathematics and science tasks typically requires reading.[23]

TIMSS collects and summarizes information about early literacy and numeracy activities through the *Early Literacy and Numeracy Activities Before Primary School* scale. This is complemented by information on how well students could perform different literacy and numeracy tasks upon school entry in the *Could Do Early Literacy and Numeracy Tasks When Beginning Primary School* scale. Both scales are included in the Home Questionnaire; these data are only available for fourth grade students.

Preprimary Education

Research has shown the importance of preprimary education (e.g., preschool, kindergarten) in influencing later academic outcomes.[24,25] High-quality preprimary education and other early childhood interventions can be especially beneficial for students from disadvantaged socioeconomic backgrounds.[26,27]

TIMSS gathers information about the types of preprimary education programs in which fourth grade students have participated, as well as the duration of their enrollment in these programs through the Home Questionnaire.

The COVID-19 Pandemic

Staying Home from School

The COVID-19 pandemic has been an immense disruption to students' educational experiences. It is impossible to predict what the state of the pandemic will be when students participate in TIMSS 2023; however, TIMSS still aims to gather some information about school that students missed because of COVID-19 disruptions. Parents are asked to indicate the amount of time during various school years (beginning with the 2019 – 2020 school year) where their child had to stay home from school for reasons related to COVID-19.

At-Home Learning

TIMSS also aims to gather information about the specific learning resources that were available to fourth grade students while they were home from school because of the COVID-19 pandemic. Parents are asked to indicate the resources their child's school provided during the pandemic. Parents are also asked if they provided particular learning resources for their child, and if they believe their child's learning progress has been negatively impacted by the COVID-19 pandemic.

School Contexts

School Characteristics

Size and Geographic Location

Internationally, schools vary in size and are located in a variety of different geographical areas (e.g., urban, suburban, rural). Smaller schools can provide more intimate learning environments, which may be beneficial for students.[28] Smaller schools in rural areas may also face particular challenges, such as lower budgets and difficulty recruiting highly qualified teachers; however, there is still great diversity in resources among rural schools.[29,30,31] Depending on the country, schools in urban or suburban areas may also have access to more educational resources outside the school (e.g., museums, libraries, bookstores) than schools in rural areas.

TIMSS obtains information about school size and geographic area through the School Questionnaire for the both fourth and eighth grades.

Composition of the Student Body

Socioeconomic Background

The relationship between socioeconomic composition of a school's student body and individual student achievement has been of sustained interest since the Coleman Report.[32,33,34] There is evidence that students from disadvantaged backgrounds may have higher achievement if they attend schools where the majority of students are from advantaged backgrounds, which some have attributed to peer effects.[35,36,37]

In some countries, schools with high proportions of disadvantaged students have difficulty attracting highly qualified teachers.[38,39]

TIMSS obtains information about the socioeconomic backgrounds of students within schools through the School Questionnaire for both fourth and eighth grades, which asks principals to report the percentages of students from economically disadvantaged and affluent homes.

Languages Spoken in the School

Schools vary in their linguistic diversity. Students who speak a language other than the primary language of instruction may require additional support and resources to support their academic success, and schools vary in the resources and support they provide.

TIMSS obtains information about the percentage of students for whom the language of the TIMSS assessment is their native language through the School Questionnaire for both fourth and eighth grades.

Literacy and Numeracy Skills of Entering Student Body

Students who enter the first grade of primary school with literacy and numeracy skills have a stronger foundation for formal mathematics and science education. The TIMSS 2023 School Questionnaire asks principals to estimate the percentage of students who can do various literacy and numeracy tasks when they enter first grade, including reading words and sentences, recognizing written numbers, and doing simple arithmetic. This information is only collected for the fourth grade and is summarized in the *Schools Where Students Enter the Primary Grades with Literacy and Numeracy Skills* scale.

School Resources

Resources for Mathematics and Science Instruction

Adequate facilities and sufficient instructional resources are important for maintaining favorable school learning environments.[40] Although "adequacy" of resources can be relative, the supply and quality of school resources have been shown to be critical for quality instruction.[41,42] Important resources include well-maintained school facilities, qualified staff, and access to adequate technologies (e.g., computers, tablets, software) for instruction.

TIMSS conceptualizes school resources as both general and subject-specific, collecting information on general resources such as school building facilities and instructional space or materials, as well as resources specific to mathematics and science instruction. These subject-specific resources include teachers with specialized training in mathematics or science, relevant library resources for mathematics and science, and materials for carrying out hands-on science experiments or investigations. The *Instruction Affected by Mathematics Resource Shortages – Principals' Reports* and *Instruction Affected by Science Resource Shortages – Principals' Reports* scales summarize this information for both the fourth and eighth grades.

School Climate

School Emphasis on Academic Success

A school atmosphere of academic optimism and emphasis on student success can contribute positively to overall school climate, and academic achievement.[43,44,45] Such an atmosphere includes an overarching emphasis on academics, collective efficacy in promoting academic performance, and trust among a school's staff, students, and parents.[46,47]

TIMSS collects information about school emphasis on academic success through both the School and Teacher Questionnaires for the fourth and eighth grades and summarizes this information in the *School Emphasis on Academic Success – Principals' Reports* and *Teachers' Reports* scales.

School Emphasis on Mathematics and Science

Schools can vary in the degree to which they emphasize mathematics and science. Some schools may offer special initiatives to promote student interest in mathematics and science, such as after-school activities or targeted exposure to careers utilizing mathematics and science. TIMSS collects information about these kinds of initiatives through the eighth grade School Questionnaire.

Teacher Job Satisfaction and Challenges

Fostering teacher job satisfaction is important in retaining qualified teachers in the classroom.[48] Research has shown that teachers who remain in the classroom are often motivated by collaboration with colleagues, strong principal leadership, and meaningful relationships with students.[49,50,51] Conversely, challenges that teachers encounter may lead them to leave the classroom or diminish the quality of instruction they provide. Such challenges include large class sizes, lack of planning time, and keeping up with curricular changes.

TIMSS gathers information about both fourth and eighth grade teachers' job satisfaction through the *Teacher Job Satisfaction* scale. Several questions in the Teacher Questionnaire also ask teachers to indicate the degree to which they experience various challenges.

Students' Sense of School Belonging

Students' sense of school belonging, also referred to as school connectedness, has been found to contribute to general well-being and academic achievement.[52,53,54] Students with a strong sense of school belonging feel safe at school, enjoy school, and have good relationships with their teachers and peers.

TIMSS collects information about fourth and eighth grade students' sense of school belonging through the *Students' Sense of School Belonging* scale on the Student Questionnaire.

Parents' Perceptions of Their Child's School

Parents and guardians can vary in their perceptions of their children's schools, although research shows that many are satisfied with the schools their children attend.[55,56] TIMSS collects this information for the fourth grade only via the *Parent's Perceptions of Their Child's School* scale.

School Discipline, Safety, and Bullying

School Discipline and Safety

School safety is an important prerequisite for student achievement in many countries.[57,58] Respect for individual students and teachers, a safe and orderly environment, and constructive interactions among teachers and administrators are all associated with higher student achievement.[59,60] Research shows that schools where rules are clear and enforced fairly tend to have atmospheres of greater discipline and safety.[61]

TIMSS collects information regarding school discipline and safety from both principals and teachers at the fourth and eighth grade. These data are summarized in the *School Discipline – Principals' Reports* scale and the *Safe and Orderly Schools – Teachers' Reports* scale.

Student Bullying

Bullying is a unique aspect of school safety because it involves repeated aggressive behavior intended to intimidate or harm students. Bullying can take a variety of forms, both mental and physical, and may occur in person or virtually. Cyberbullying through both online games and social media has become more prevalent as access to digital devices among children has increased.[62,63,64] Experiencing in-person or cyberbullying causes distress to victims and is associated with poorer academic achievement.[65,66,67]

TIMSS collects information regarding the frequency of student bullying from fourth and eighth grade students and summarizes this information in the *Student Bullying* scale for each grade.

Principal Preparation and Years of Experience

Principals act as leaders in schools by overseeing school staff, students, and the school environment. Research has shown that strong principal leadership can foster student achievement by creating an atmosphere of collective efficacy through a positive school climate and trust among teachers.[68,69] Additionally, rapid principal turnover can lead to decreases in student achievement.[70,71]

TIMSS collects information about principal preparation and years of experience through the School Questionnaire for both the fourth and eighth grades.

The COVID-19 Pandemic

School Closure and Remote Learning

TIMSS 2023 also aims to collect information regarding the COVID-19 pandemic at the school level. Principals are asked to indicate how long their schools were fully closed for in-person instruction because of the pandemic during relevant school years (beginning with the 2019 – 2020 school year). They are also asked to indicate whether or not specific resources related to remote learning were provided for students and teachers during these times.

Classroom Contexts

Teacher Characteristics

Preparation and Years of Experience

Quality teacher preparation is critical for effective teaching.[72] Teachers' subject-specific knowledge can have positive impacts on student achievement in conjunction with their pedagogical skills.[73] Teaching experience is also important for teacher development, especially in the early years of teaching.[74,75] Research has shown that teachers continue to develop pedagogical skills after five years of experience, which can positively impact student achievement.[76]

TIMSS collects information about teacher preparation, including the highest level of education completed and any subject-matter specializations, through the Teacher Questionnaire for both the fourth and eighth grades. Teachers are also asked to indicate the number of years they have spent teaching.

Professional Development

Professional development is an important component of continuing education for the teaching profession, and teacher participation in effective professional development activities can lead to positive changes in teacher practices.[77] Effective professional development engages teachers through concrete tasks, is sustained and ongoing, and provides teachers space to reflect on their teaching.[78] Teachers are more likely to participate in professional development when they are encouraged and supported to do so.[79]

TIMSS obtains teacher professional development information through the Teacher Questionnaire for both the fourth and eighth grades. Teachers are asked to indicate topics for which they have participated in professional development, as well as those for which they feel they need professional development.

Mathematics and Science Instruction

Instructional Time

The amount of instructional time that teachers have to teach the mathematics and science curricula is an important aspect of curriculum implementation. Research has found instructional time to be related to student achievement, although such relationships depend on how efficiently and effectively instructional time is used.[80,81]

TIMSS gathers information about instructional time through the Teacher Questionnaire for fourth and eighth grades. Teachers indicate the number of minutes spent on mathematics and science instruction each week with the students participating in the TIMSS assessment.

Instructional Strategies

Teachers vary in their instructional strategies, both internationally and within countries.[82] Effective instruction in mathematics can include practices such as asking students to explain their answers or purposefully practice mathematical procedures.[83,84] Hands-on activities and experiments can be helpful in promoting students' understanding of science, although research suggests that such activities should be appropriately scaffolded and supported.[85,86]

TIMSS obtains information about instructional practices in teaching mathematics and science through the Teacher Questionnaire for the fourth and eighth grades. Teachers indicate how often they perform or ask students to perform various activities during instruction, including working out practice mathematics problems or making observations about the world around them.

Instructional Clarity

Instructional clarity concerns students' perceptions of teachers' instructional strategies.[87] Teachers with a high degree of instructional clarity provide straightforward explanations of content and effectively monitor student understanding, employing a variety of pedagogical techniques as required.[88,89] Linking instruction to students' prior knowledge is also likely to increase instructional clarity.[90] Instructional clarity is also related to establishing a supportive classroom climate where teachers engage in practices such as providing helpful feedback and clearly addressing student questions.[91] Instructional clarity has been shown to have positive relationships with student achievement.[92]

TIMSS measures students' perceptions of their teachers' instructional clarity through the Student Questionnaire at the fourth and eighth grades as a complement to teachers' reports of their instructional strategies. Their responses are summarized in the *Instructional Clarity* scales for mathematics and science lessons. Eighth grade students enrolled in separate science subjects provide information for each subject in which they are enrolled.

Emphasis on Science Inquiry

Student inquiry is an important component of science education; however, its relationships with academic achievement are not necessarily straightforward.[93] Some research utilizing TIMSS data from past cycles suggests that frequency of inquiry may not be the most effective aspect to capture, as its relationship with achievement is not necessarily linear.[94] There are many aspects of scientific inquiry in which teachers can engage students, including the articulation of research questions or hypotheses, creating models and explanations, and effectively communicating results of investigations.[95]

TIMSS collects information about science inquiry emphasis and activities through the Teacher Questionnaire for the fourth and eighth grades. Science teachers indicate how often they ask students to carry out different types of investigations (e.g., open investigations of concepts, experiments with prescribed steps), as well as the degree to which they emphasize different aspects of the science inquiry process.

TIMSS Mathematics and Science Topics Taught

TIMSS collects information about teaching of the mathematics and science topics in the TIMSS 2023 assessment through the Teacher Questionnaire for fourth and eighth grade. Content exposure is an important component of students' opportunity to learn mathematics and science.[96,97] Teachers are asked to indicate whether specific topics or concepts have been covered in their own instruction, have been taught in previous years or schooling, or have not yet been taught.

Homework

Assignment of homework in mathematics and science varies both within and across countries, with some countries having policies that fourth grade students should not be assigned homework. The relationship between time spent on homework, types of homework assigned, and student achievement is not straightforward and may vary depending upon a particular country's context and policies.[98,99]

TIMSS collects information about homework through the Teacher Questionnaire for fourth and eighth grades, as well as the Student Questionnaire for eighth grade only. Teacher Questionnaire items ask how often homework is assigned and how homework is used in class, while the Student Questionnaire asks how often homework is assigned.

Classroom Assessment

Classroom assessment is an important component of teaching, serving both formative and summative functions.[100] Teachers have a number of ways to monitor student progress and achievement, including observing students as they work, asking students to answer questions during class, or administering written assessments. Results of these classroom assessments can help teachers engage with students and determine the best course of action during instruction. Clarifying or re-teaching concepts on the basis of a variety of ongoing classroom assessment strategies can improve student achievement.[101,102]

TIMSS gathers information about classroom assessment through the Teacher Questionnaire for the fourth and eighth grades. Teachers indicate the importance they place on various assessment strategies for gathering information about student learning, including observations, written assessments, and long-term projects.

Information Technology in the Classroom

Access to Digital Devices for Instruction

Access to digital devices is a necessary prerequisite for their use in instruction. Within and across countries, schools and classrooms vary in access to devices such as computers and tablets. TIMSS gathers information about access to digital devices during mathematics and science instruction through the Teacher Questionnaire for the fourth and eighth grades. Teachers indicate the type of access students have to digital devices, including school-owned devices shared among students and provisions for students to bring their own devices to school.

Uses of Digital Devices During Instruction

There are many ways that digital devices might be used in mathematics and science instruction. Teachers can utilize digital devices and other technologies to differentiate and personalize instruction for students, engage in classroom assessment, or promote exploration of concepts through games and activities.[103,104,105] Use of digital devices for instruction both within and outside of the classroom has also expanded considerably in response to the COVID-19 pandemic.

TIMSS obtains information about use of digital devices during mathematics and science instruction through the Teacher Questionnaire for the fourth and eighth grades. Teachers are asked to indicate how

often they use digital devices for various instructional purposes, including simulated experiments and problem-solving activities.

Challenges Using Digital Devices During Instruction

TIMSS 2019 results highlighted integration of technology within mathematics and science instruction as a preferred area of professional development for teachers.[106] Research has shown that factors such as availability of professional development, on-site technological support, and teacher self-efficacy in working with technology can all impact use of digital devices in the classroom, and that the impacts of these factors varies internationally.[107,108,109] Using digital devices as part of effective instruction can depend on a number of factors beyond efficacy in using the devices. Teachers must meaningfully integrate digital devices in their lessons, as well as manage simultaneously both the devices and their instruction.

TIMSS obtains information about the challenges of integrating technology into mathematics and science instruction through the Teacher Questionnaire. Teachers indicate the extent to which lack of resources, difficulties in instructional management, or challenges meaningfully integrating devices into lessons limit their use of digital devices during instruction.

Classroom Climate

Classroom Management

Classroom management refers to noninstructional procedures that promote student learning and discourage disruptive behavior.[110] Although direct links between classroom management and student achievement are difficult to establish, some research suggests that effective classroom management has indirect, positive effects on student achievement.[111,112]

TIMSS obtains information on classroom management from fourth and eighth grade students. For students, this information is summarized in the *Disorderly Behavior During Mathematics or Science Lessons* scales. Eighth grade students enrolled in separate science subjects complete this scale for each subject in which they are enrolled.

Instruction Limited by Student Attributes

Attributes that students bring with them to the classroom can limit the impact of instruction. For example, research has shown that students lacking basic nutrition tend to have lower academic achievement.[113,114] Lack of sleep or prerequisite knowledge, as well as absences may negatively impact the effects of mathematics and science instruction.

TIMSS obtains information about these limiting factors through the Teacher and Student Questionnaires for the fourth and eighth grade. The Teacher Questionnaire contains items asking the extent to which teachers find their instruction limited by various student attributes and summarizes these responses in the *Classroom Teaching Limited by Students Not Ready for Instruction* scale. The Student Questionnaire asks students how often they feel tired or hungry when they are at school, as well as how often they are absent from school.

Student Attributes

Student Demographics

TIMSS collects basic student demographic information through the Student Questionnaire for both fourth and eighth grade. Students indicate their age, gender, and whether they were born in the country in which they are assessed.

Attitudes Toward Mathematics and Science

Liking Mathematics and Science

Students who enjoy mathematics and science find the subjects interesting and are likely to be more intrinsically motivated in mathematics and science classes. Intrinsic motivation influences behavior,[115] and students who like mathematics and science may have higher achievement and be more likely to choose courses in these subjects later in schooling.[116,117] These relationships can be reciprocal; students who do well in mathematics and science may be more likely to have positive attitudes towards the subjects.

TIMSS measures fourth and eighth grade students' liking of mathematics and science through the *Students Like Learning Mathematics* and *Students Like Learning Science* scales. For countries where eighth grade science is taught as separate subjects, students complete this scale for each of the science subjects in which they are enrolled.

Confidence in Mathematics and Science

Students tend to have distinct views of their abilities in different subjects, and their self-appraisal is often based on past experiences and how they see themselves compared with their peers.[118] Students who are confident in a particular subject persevere through challenging material because they believe they will ultimately succeed.[119] Additionally, anxiety or a lack of confidence in a subject is associated with lower achievement.[120,121]

TIMSS measures fourth and eighth grade students' confidence in mathematics and science through the *Students Confident in Mathematics* and *Students Confident in Science* scales. For countries where eighth grade science is taught as separate subjects, students complete this scale for each of the science subjects in which they are enrolled.

Valuing Mathematics and Science

Students who value mathematics and science are extrinsically motivated to learn these subjects because of future opportunities, such as entrance into desirable educational programs or a well-paying career. Some research has shown that such motivation is associated with choosing science courses later in schooling, particularly for students from disadvantaged backgrounds[122]. Additionally, students who articulate an interest in science careers in primary or early secondary school are more likely to actually pursue those careers.[123]

TIMSS measures students' valuing of mathematics and science for the eighth grade only using the *Students Value Mathematics* and *Students Value Science* scales.

Information Technology and Digital Devices

Use of Digital Devices

Students vary in their uses of digital devices, both at home and in school.[124] TIMSS collects this information through the Student Questionnaire for the eighth grade. Students indicate how often they use the internet for specific tasks, including accessing course materials, collaborating with classmates, or asking questions of teachers.

Digital Self-Efficacy

Although students participating in TIMSS 2023 have greater access to information technology and digital devices than past generations, it is a mistake to assume that they innately understand how they work.[125] Students vary in both their actual knowledge of digital devices, as well as their self-efficacy for using them.[126,127]

TIMSS collects information regarding fourth and eighth grade students' self-efficacy in the use of information technology through the *Digital Self-Efficacy* scale. Students indicate how well they can perform simple digital tasks, such as writing text, as well as more complex tasks, such as recognizing trustworthy websites and learning to use new apps or programs.

National Contexts

In every country, the educational system is embedded in a unique configuration of historical, economic, and language factors that combine to determine priorities in how the system is organized for teaching and learning. In addition to the more granular data described in the previous sections, TIMSS also gathers information on system-level characteristics that may contribute to students' learning of mathematics and science. Countries participating in TIMSS 2023 contribute information on many of these factors through chapters in the *TIMSS 2023 Encyclopedia*, along with information collected through the curriculum questionnaire. In particular, information collected on national contexts focuses on countries' organization of their education systems and their mathematics and science curricula. Specific curricular information is collected for both the fourth and eighth grades.

Organization of Education System

System for Preprimary Education

Even before they begin formal primary school, children receive considerable exposure to literacy, numeracy, and science as part of their preprimary educational experiences (e.g., preschool, kindergarten). Preprimary education is an area of investment for many countries. Research indicates that attending preprimary programs can have a positive impact on later academic outcomes.[128] The TIMSS curriculum questionnaire gathers information on the different types of early childhood and preprimary education available within countries.

Research has also shown that that the positive effects of preprimary education on later academic outcomes are dependent on the quality of the preprimary program.[129,130] TIMSS gathers information on

any available curricular documents for early childhood and preprimary education, including provisions for socioemotional development as well as for the development of literacy and numeracy skills. This serves to contextualize the information on student participation in preprimary education that is collected through the Home Questionnaire.

Age of Entry and Retention Policies

Because TIMSS assesses students in the grades corresponding to the fourth and eighth years of formal schooling, policies about the age of entry into formal education (first year of primary school, ISCED Level 1) are important for understanding variation in achievement and students' ages within those grades across countries.[131] Countries' promotion and retention policies during different phases of schooling are also collected; research has shown that retention has negative relationships with student well-being and achievement, particularly in the short term.[132,133,134]

Number of Years of School

Although only fourth and eighth grade students participate in TIMSS, these grades are situated within a sequence of schooling that shapes the national context in which students learn. For this reason, TIMSS collects data on nationally mandated and provided years of education.

Language(s) of Instruction

Some countries have one commonly spoken language, while others are historically multilingual. Immigration has also increased the language diversity in many countries over time. TIMSS collects data on any official languages of instruction, as well as if mathematics and science instruction is typically presented to students in their native language.

Teacher and Principal Preparation

Information about the preparation of the teachers and principals whose students participate in TIMSS is collected through the Teacher and School Questionnaires; this is complemented by the information on the most typical preparation routes for teachers and principals within each country.

Mathematics and Science Curricula

Whether created at the national, provincial, community, or school level, curricular documents define and communicate the curriculum that specifies expectations for students in terms of the knowledge, skills, and attitudes to be developed or acquired through their formal mathematics and science education.

Mathematics and science curricula differ across countries and are constantly evolving, although there is some evidence of curricular convergence over time.[135] In mathematics, countries differ in the degree of emphasis placed on acquiring basic skills, memorizing rules, procedures, or facts, understanding mathematical concepts, applying mathematics to real life situations, and communicating or reasoning mathematically. In science, countries vary in the extent to which they focus on acquiring basic science facts, application of science concepts, formulating hypotheses and carrying out scientific investigations, and communicating scientific explanations. At the eighth grade, countries differ as to whether science is taught as a single subject or as separate science subjects (physics, chemistry, biology, and earth science).

TIMSS collects information on countries' coverage of the mathematics and science topics articulated in the *TIMSS 2023 Mathematics Framework* and *TIMSS 2023 Science Framework*, as well as any curricular specifications or mandates for incorporation of technology into instruction. Such information is essential for contextualizing the performance of each country's students on the TIMSS assessment.

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