CHAPTER 3:

TIMSS 2027 Contextual Framework

Katherine A. Reynolds
Audrey Gallo
Deepthi Kodamala

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 student background, learning environments and student achievement. Broadly speaking, greater opportunities to learn and more supportive learning environments both at home and at school are consistently associated with higher mathematics and science achievement both across and within countries.

TIMSS contextual data are an important resource for research on improving mathematics and science education, and this information is used to support and characterize aspects of the TIMSS mathematics and science achievement results, as well as enabling investigation of topics related to educational equity. Some context variables have been collected for many cycles of TIMSS because of their ongoing relevance, and other indicators are added or removed each cycle to address changes in research and policy interests over time.

The TIMSS 2027 Contextual Framework describes the different types of contextual information to be collected in TIMSS 2027. Similar to previous TIMSS cycles, the framework focuses on the five areas of influence on students' mathematics and science achievement: home contexts; school contexts; classroom contexts; student characteristics, attitudes, and behaviors; and national contexts. Relationships among these sources of influence are discussed at the beginning of the Contextual Framework, which then continues with an elaboration of specific topics within each area that are included in the TIMSS 2027 context questionnaires.

TIMSS 2027 Contextual Data Collection Sources

The contextual information available in TIMSS 2027 consists of quantitative data obtained through questionnaires, as well as qualitative data collected through participants' Encyclopedia chapters. Each of these data sources is described below.

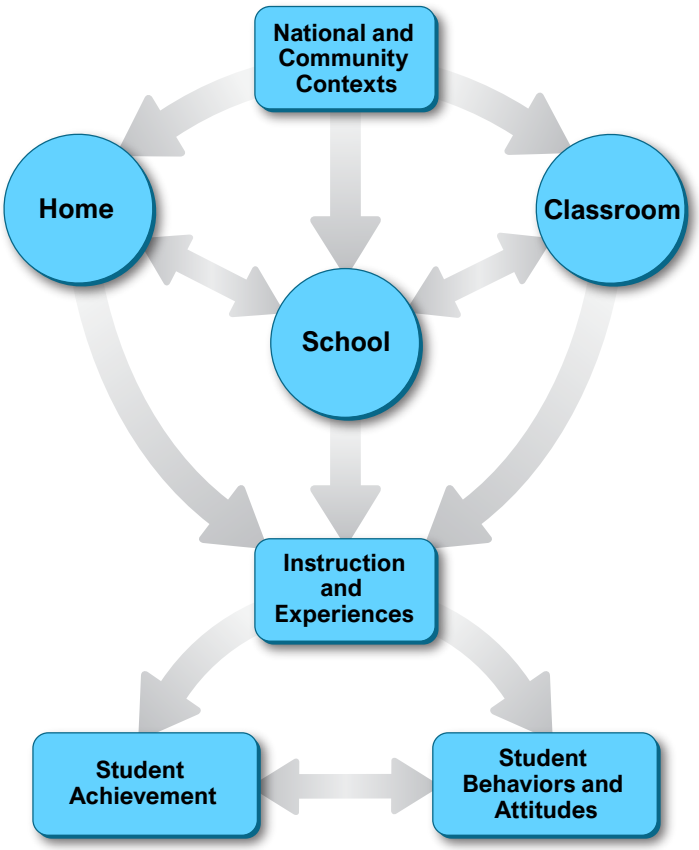
- **Student Questionnaire:** This questionnaire is completed by fourth- and eighth-grade students following the mathematics and science assessment. Two versions of this questionnaire are provided for the eighth grade: one for students who take science as an integrated subject and one for students enrolled in separate science subjects (biology, chemistry, physics, and earth science).
- **Home Questionnaire:** This questionnaire is completed by the parents or primary caregivers of the students participating in TIMSS. Previous cycles of TIMSS administered the Home Questionnaire only to parents of fourth-grade students; TIMSS 2027 also includes a Home Questionnaire for parents of eighth-grade students.
- **School Questionnaire:** This questionnaire is completed by the principal of each participating school.
- **Teacher Questionnaire**: This questionnaire is completed by students' mathematics and science teachers. There is typically one classroom teacher for fourth-grade students and separate mathematics and science teachers for eighth-grade students.
- **Curriculum Questionnaire:** This questionnaire is completed by the National Research Coordinator (NRC) for each participating country with assistance from curriculum experts as necessary.
- ***TIMSS 2027 Encyclopedia* Chapters:** Chapters are written by NRCs or other representatives of participating countries.

The Student, Home, School, and Teacher Questionnaires cover similar topics for the fourth and eighth grades, although some items may be unique to the different grade versions based on appropriateness of certain topics for primary or lower secondary school contexts. The Curriculum Questionnaire includes general items that are identical across the fourth and eighth grades, as well as items that are grade- and subject-specific. All countries follow a common outline for the Encyclopedia chapters, regardless of the grade(s) at which they participate in TIMSS 2027.

Contexts for Student Learning in Mathematics and Science

Students' academic achievement, attitudes, and behaviors must be evaluated in the context of their instructional and personal experiences. Students' experiences are shaped through a complex interaction of contexts at home, in school, in the community, and in society at large. The contexts for student learning presented in Exhibit 1 account for the complex interactions between different factors that shape students' educational experiences and outcomes, similar to the dynamic model of educational effectiveness.[1] The exhibit is not intended to show a deterministic model; rather, it provides a useful structure for thinking about how student achievement in mathematics and sciences relates to other aspects of educational experiences and systems.

Exhibit 1: Contexts for Student Learning



The upper portion of Exhibit 1 depicts the school at the center, which is shaped by inputs from the home, classroom, and broader national and community contexts. The lower portion depicts the relationship between students' achievement in mathematics and science and their corresponding behaviors and attitudes regarding these subjects. The bidirectional arrow between the boxes indicates a reciprocal relationship, meaning these areas are hypothesized to influence each other. Much research has supported this assertion, although the exact nature of this influence (including the predominant direction of causality) is unknown and may vary across national or cultural contexts.[2,3]

Data on student achievement, behaviors, and attitudes are all observed through the lens of assessments and self reports. To contextualize these, it is important to also collect data on instruction students experience in school, as well as their life experiences both in and outside of school. Mathematics and science instruction is intended to foster students' understanding of these subjects, but may also interact with and shape their thoughts and feelings about the subjects. Students' personal experiences outside of direct instruction may also play a role in the development of achievement, behaviors and attitudes.

Students' engagement with instruction and life experiences takes place in a combination of the home, school, and classroom spaces in which students spend their time. Each of these spaces draws from characteristics of those who occupy them (for example, parents, teachers, or principals), as well as broader national and community contexts.

The TIMSS 2027 Contextual Framework distills this network of relationships into five broad hierarchical areas. These areas are reflected in the questionnaires that are administered as part of

TIMSS 2027. Note that some components that are specified individually in Exhibit 1 are combined for the purposes of this discussion. The five areas are:

- National Contexts
- Home Contexts
- School Contexts
- Classroom Contexts
- Student Characteristics, Attitudes, and Behaviors

The remainder of the framework provides details about the topics related to each area that are covered in the TIMSS 2027 Context Questionnaires. Information about how TIMSS 2027 conceptualizes mathematics and science achievement can be found in the TIMSS 2027 Mathematics Framework and TIMSS 2027 Science Framework.

Home Contexts

Students' home contexts are part of their informal learning experiences and also interact with school contexts to shape their formal learning experiences. Information about students' home contexts is collected through the Student and Home Questionnaires for both fourth and eighth grade. The topics included in these questionnaires are summarized in Exhibit 2.

Exhibit 2: Summary of Home Contexts Topics and Sub-Topics

Topic	Sub-Topic	Grade(s)
Home Environment	Socioeconomic Status and Home Resources	Grade 4 & Grade 8
	Language(s) Spoken at Home	Grade 4 & Grade 8
	Family Involvement in Children's Education*	Grade 4 & Grade 8
	Children's Use of Digital Devices at Home*	Grade 4
Early Learning Experiences	Early Literacy and Numeracy Activities	Grade 4
	Early Literacy and Numeracy Skills at School Entry	Grade 4

* Indicates a new topic introduced in TIMSS 2027. Topics that are not new may have different items than in previous TIMSS cycles.

Home Environment

Socioeconomic Status and Home Resources

Socioeconomic status (SES) was found to exhibit a consistent relationship with students' academic achievement.[4,5,6] SES and resources available at home consistently display some of the strongest relationships with mathematics and science achievement in previous TIMSS cycles.[7,8] This pattern holds across a wide range of countries participating in IEA studies, and socioeconomic academic achievement gaps have grown within the past few decades.[9,10] SES is often measured through proxy variables, including parental level of education and occupation. Although there are challenges when measuring SES across cultures, parental education and occupation have been successfully used as SES indicators in a large number of surveys.[11] TIMSS 2027 complements these indicators with 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. TIMSS 2027 collects information about home resources in the Student and Home Questionnaires.

Language(s) Spoken at Home

There are many reasons why children might not speak their school's language of instruction at home, and these reasons vary across different country contexts. For example, countries may have numerous national languages or large immigrant populations that speak a language different from the language of instruction in schools. Learning mathematics or science in a language other than the one that is primarily spoken at home can pose difficulties for students because they are learning both curricular concepts and a less familiar or unfamiliar language.[12,13] Results from previous cycles of TIMSS suggest that having at least some familiarity with the language of the assessment is associated with higher achievement, although always speaking the language of the assessment at home is not necessarily associated with the highest achievement.[14] TIMSS 2027 collects information about the language(s) students speak at home in the Student and Home Questionnaires.

Family Involvement in Children's Education

There are many ways in which parents and families can contribute to children's education, ranging from casual (for example, asking about the school day) to more involved (for example, assisting with schoolwork). Parent/family engagement with the school itself also exists along a continuum,[15] and expectations and opportunities for family involvement in school varies considerably across countries. Parents' and families' perceptions of children's schools can be affected by many factors, such as how well the school communicates about academic progress or respects families from different backgrounds.[16] TIMSS 2027 collects information about family involvement in children's education in the Student and Home Questionnaires. Information about parents' perceptions of their child's school is collected in the Home Questionnaire.

Children's Use of Digital Devices at Home

As the availability of digital devices has expanded, concerns have been raised about the impact of screen time on children. Some studies suggest that large amounts of screen time are associated with decreased academic performance and other outcomes related to children's well-being.[17] However, there is also some evidence that the relationship between screen time and academic performance differs for households of different socioeconomic status.[18] TIMSS 2027 collects information about whether parents of fourth-grade students have rules about time spent on digital devices at home in the Home Questionnaire.

Early Learning Experiences

Early Literacy and Numeracy Activities

Early childhood learning activities are often cited as having positive relationships with students' education outcomes.[19,20,21] Early numeracy activities at home may relate to later mathematics performance and to students' mathematics self-efficacy.[22] Engaging children in early numeracy activities may also relate to their interest in mathematics and the development of numeracy skills.[23,24] Data from earlier TIMSS cycles shows that many parents across countries report

engaging in early literacy and numeracy activities with their children, and that doing so is positively associated with mathematics and science achievement.[25] TIMSS 2027 collects information about early literacy and numeracy activities in the fourth-grade Home Questionnaire.

Early Literacy and Numeracy Skills at School Entry

Students who enter primary school with basic literacy and numeracy skills have a stronger foundation for primary school than students who are lacking these skills. Analyses of data from previous cycles of TIMSS provide evidence for a relationship between students' abilities to perform early literacy and numeracy tasks at primary school entry are associated with higher achievement.[26] Early literacy skills may be particularly important because reading skills are required to understand many mathematics and most science questions.[27] TIMSS 2027 collects information about fourth-grade students' early literacy and numeracy skills before entering primary school in the Home Questionnaire.

School Contexts

As the formal providers of instruction, schools play an essential role in students' educational experiences. Information about students' school contexts is collected through the School, Teacher, and Home Questionnaires for both fourth and eighth grade. The topics included in these questionnaires are summarized in Exhibit 3.

Exhibit 3: Summary of School Contexts Topics and Sub-Topics

Topic	Sub-Topic	Grade(s)
School Characteristics and Composition of Student Body	School Geographic Location	Grade 4 & Grade 8
	Socioeconomic Background of Student Body	Grade 4 & Grade 8
	Language Spoken by Student Body	Grade 4 & Grade 8
	School Readiness	Grade 4
School Climate	School Safety	Grade 4 & Grade 8
	School Emphasis on Academic Success	Grade 4 & Grade 8
	School Engagement with Students' Families*	Grade 4 & Grade 8
	Teacher Job Satisfaction and Challenges	Grade 4 & Grade 8
	Resources for Mathematics and Science Instruction	Grade 4 & Grade 8
	School Emphasis on Environmental Sustainability	Grade 4 & Grade 8
School Resources and Technology	Availability of Computers and Internet	Grade 4 & Grade 8
	Policies Regarding Technology Use*	Grade 4 & Grade 8
Principal Characteristics	Qualifications and Years of Experience	Grade 4 & Grade 8
	Leadership Practices*	Grade 4 & Grade 8

* Indicates a new topic introduced in TIMSS 2027. Topics that are not new may have different items than in previous TIMSS cycles.

School Characteristics and Composition of Student Body

School Geographic Location

Schools are located in a variety of different geographical areas (e.g., urban, suburban, rural). It is not possible to make internationally applicable generalizations about the relation of school location to students' academic achievement; however, this still provides important information that characterizes students' school experiences. TIMSS 2027 collects information about schools' geographic location in the School Questionnaire.

Socioeconomic Background of Student Body

Since the publication of the Coleman report in the United States,[28] there has been sustained interest in how the socioeconomic composition of schools is related to the achievement of individual students.[29,30,31] This relationship between socioeconomic composition of schools and achievement is not necessarily uniform across countries and may be impacted by country-level factors, such as use of student tracking.[32] The mechanisms that promote socioeconomic segregation or integration across schools (e.g., school choice policies[33]) and contribute to its effects on schools are also likely to vary across countries (e.g., fundraising practices or access to highly qualified teachers).[34,35] TIMSS 2027 collects information about the socioeconomic composition of schools in the School Questionnaire.

Language Spoken by Student Body

Schools vary in their linguistic diversity, and this diversity depends on many country-specific contextual factors—for example, countries may have large immigrant populations, or it may be common practice for schooling to take place in a second language. TIMSS 2027 collects information about the percentage of students in schools who have the language of instruction as their native language in the School Questionnaire.

School Readiness

Students who enter the first grade of primary school with some literacy and numeracy skills have a stronger foundation for formal mathematics and science education. Schools where a larger proportion of students begin primary education without these skills may need to expend additional resources to enable students to effectively engage with on-grade instruction. TIMSS 2027 collects information about the percentage of students entering school with basic literacy and numeracy skills in the School Questionnaire.

School Climate

School Safety

School safety is an important variable related to student achievement in many countries and is an important factor in school climate.[36,37] Respect for individual students and teachers and a safe and orderly environment are associated with higher student achievement.[38,39] Some research suggests that schools where rules are clear and enforced fairly tend to have atmospheres of greater discipline and safety.[40] TIMSS 2027 collects information about school safety in the Teacher and School Questionnaires.

School Emphasis on Academic Success

Teaching, learning, and the organizational culture surrounding these processes are important contributors to school climate.[41] A school atmosphere of academic optimism and high expectations for academic excellence can contribute to school success.[42,43] 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.[44,45] TIMSS 2027 collects information about school emphasis on academic success in the School Questionnaire.

School Engagement with Students' Families

Schools can engage with students' families in a variety of ways, including regular communication (such as newsletters or emails) and hosting academic or community-building events. The ways in which schools promote family engagement may vary across country contexts. TIMSS 2027 collects information about how schools engage with students' families in the School Questionnaire.

Teacher Job Satisfaction and Challenges

Teacher job satisfaction is important for retaining qualified teachers in the classroom and promoting instructional quality.[46,47] Teachers may also encounter challenges such as large class sizes, lack of planning time, and frequent curricular changes that compromise their teaching. TIMSS 2027 collects information about teacher job satisfaction and challenges in the Teacher Questionnaire.

Resources for Mathematics and Science Instruction

Adequate facilities and sufficient instructional resources are important for maintaining favorable school learning environments.[48] Although "adequacy" of resources can be relative, the supply and quality of school resources have been shown to be critical for quality instruction, especially in less wealthy countries.[49,50] 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. TIMSS 2027 collects information about school resources for teaching mathematics and science in the School Questionnaire.

School Emphasis on Environmental Sustainability

Schools are formative environments which are hypothesized to influence children's and adolescents' environmental attitudes and behaviors.[51,52] A shared vision and a schoolwide approach to sustainability education can give a clear direction to teachers and encourage collaboration for integrating sustainability in educational processes.[53, 54,55] School practices can serve as models of sustainable behavior for students as they provide examples of applying sustainability principles in everyday life; they can also provide opportunities for students to participate in environmentally responsible activities. Integrating sustainability principles in schools' everyday practices can be understood as one way of promoting environmentally sustainable attitudes and behaviors in students.[56,57] TIMSS 2027 collects information about how frequently schools engage in activities to promote environmental sustainability, as well as whether students

have opportunities to participate in environmentally responsible activities at school, in the School Questionnaire.

School Resources and Technology

Availability of Computers and Internet

Increased use of computers and the internet in schools has created new opportunities for teaching and learning while simultaneously generating challenges related to access, implementation, and appropriate use.[58] Schools vary in the availability of computers for student use; some schools may provide students with individual devices, whereas others may have more traditional computer labs. TIMSS 2027 collects information about types of computer access for students, as well as internet access for students and teachers, in the School Questionnaire.

Policies Regarding Technology Use

School-level priorities and rules related to technology use are designed to influence teachers' and students' use of technology.[59] With the rapid evolution of technologies such as generative artificial intelligence, school policies on the use of these technologies can aim to influence their integration into teaching and learning. Similarly, mobile phones present challenges such as student distraction, although they may also have potential learning uses.[60] TIMSS 2027 collects information about school policies related to the use of artificial intelligence (for students and teachers) and student access to personal mobile phones at school in the School Questionnaire.

Principal Characteristics

Qualifications and Years of Experience

Principals act as leaders in schools by overseeing school staff, students, and the school environment. Some studies suggest that strong principal leadership can foster student achievement by creating an atmosphere of collective efficacy through a positive school climate and trust among teachers.[61,62] TIMSS 2027 collects information about principal years of experience and credentials in school leadership in the School Questionnaire.

Leadership Practices

Principals serve as the instructional leaders of their schools and can demonstrate instructional leadership through various practices. For example, collaborative leadership for partnerships with families and teachers includes encouraging teacher and family communication, as well as a principal's presence at school-wide events, family-teacher meetings, and activities.[63] TIMSS 2027 collects information about principals' leadership practices in the School Questionnaire.

Classroom Contexts

Students are clustered into classrooms within the schools they attend. These classroom contexts contribute to student achievement by shaping students' learning experiences. Important classroom-level factors include teacher characteristics, instructional methods, access to technology, and classroom climate. Information about students' classroom contexts is collected through the Teacher and Student Questionnaires for both fourth and eighth grade. The topics included in these questionnaires are summarized in Exhibit 4.

Exhibit 4: Summary of School Contexts Topics and Sub-Topics

Topic	Sub-Topic	Grade(s)
Teacher Characteristics and Qualifications	Demographic Information	Grade 4 & Grade 8
	Preparation and Years of Experience	Grade 4 & Grade 8
	Teachers' Instructional Challenges	Grade 4 & Grade 8
Mathematics and Science Instruction	Instructional Time	Grade 4 & Grade 8
	Instructional Strategies	Grade 4 & Grade 8
	Frequency of Experiments and Inquiry-Based Activities	Grade 4 & Grade 8
	Emphasis on Environmental Sustainability	Grade 4 & Grade 8
	TIMSS Mathematics and Science Topics Taught	Grade 4 & Grade 8
	Homework	Grade 4 & Grade 8
Information Technology	Computer Use During Instruction	Grade 4 & Grade 8
	Use of Generative Artificial Intelligence Tools*	Grade 4 & Grade 8
Classroom Climate and Instructional Quality	Instructional Clarity and Supportive Classroom	Grade 4 & Grade 8
	Cognitive Activation	Grade 4 & Grade 8
	Classroom Disruptions	Grade 4 & Grade 8
	Factors Limiting Instruction	Grade 4 & Grade 8

* Indicates a new topic introduced in TIMSS 2027. Topics that are not new may have different items than in previous TIMSS cycles.

Teacher Characteristics and Qualifications

Demographic Information

TIMSS 2027 collects basic information about teacher demographics (age, gender) in the Teacher Questionnaire.

Preparation and Years of Experience

Quality teacher preparation is critical for effective teaching and can serve as a moderator for the relationship of other variables with student achievement.[64,65] Some studies suggest that teachers' subject-specific knowledge has a positive relationship with student achievement in conjunction with their pedagogical skills.[66] Teaching experience is also important for teacher development, especially in the early years of teaching.[67,68] Requirements for teacher preparation and specialization vary across countries—whereas fourth-grade students are often taught by generalist teachers, eighth-grade students are more likely to be taught by subject-specialist teachers.[69] TIMSS 2027 collects information about teacher preparation and years of experience in the Teacher Questionnaire.

Teachers' Instructional Challenges

Teachers employ a variety of skills and knowledge to provide mathematics and science instruction and experience different degrees of challenge in doing so. Pedagogical content knowledge is a useful concept for characterizing these qualities—although there are many variations of the concept, it generally comprises teachers' knowledge related to the subject they teach, as well as good practices for fostering student learning in the subject.[70] TIMSS 2027 collects information

about teachers' challenges enacting different aspects of PCK in their instruction in the Teacher Questionnaire.

Mathematics and Science Instruction

Instructional Time

Instructional time in mathematics and science is an important aspect of curriculum implementation. Increased instructional time tends to be positively related to student achievement, although such relationships depend on how effectively instructional time is used.[71,72] That is, increased instructional time is likely to have a greater impact on student achievement for students with more highly qualified teachers.[73] TIMSS 2027 collects information about mathematics and science instructional time in the Teacher Questionnaire.

Instructional Strategies

Teachers vary in their instructional strategies, both internationally and within countries.[74] Effective mathematics instruction can include practices such as asking students to explain their answers or purposefully practice mathematical procedures.[75,76] While there is general consensus that not all mathematics instruction should be devoted to memorization, automaticity of basic mathematical facts (i.e., the ability to answer a problem quickly without calculation[77]) assists students in learning more complex mathematics material.[78] Hands-on activities and experiments can be helpful in promoting students' understanding of science, although research suggests that these activities should be appropriately scaffolded and supported.[79,80] TIMSS 2027 collects information about instructional strategies for mathematics and science in the Teacher Questionnaire.

Frequency of Experiments and Inquiry-Based Activities

Student inquiry is an important component of science education; however, its relationships with academic achievement are complex.[81] Increased frequency of experiments or investigations is not necessarily associated with increased science achievement.[82] Quality of inquiry-based activities may be more important—high quality inquiry activities can include asking students to articulate research questions or hypotheses, create models and explanations, and effectively communicate results of investigations.[83] TIMSS 2027 collects information about experiments and science inquiry in the Student and Teacher Questionnaires.

Emphasis on Environmental Sustainability

Studies suggest that teaching methods vary in their effectiveness at providing quality instruction on environmental sustainability topics. Students who experience more active and interactive teaching methods (e.g., classroom discussions, research projects, excursions in nature) may have greater awareness of environmental issues, more positive environmental attitudes, and more frequent environmentally responsible behavior.[84] Effective teaching that promotes education for sustainable development includes acknowledgement of the interconnected aspects of sustainability (i.e., environmental, social, and economic) and engages students in real-world problem-solving activities.[85] TIMSS 2027 collects information about how often teachers use different strategies to teach about environmentalism and sustainability in the Teacher Questionnaire.

TIMSS Mathematics and Science Topics Taught

"Opportunity to learn" refers to whether students have been exposed to particular topics in mathematics and science; students may demonstrate poorer performance if they have not been taught assessment content.[86] Although opportunity to learn does not provide a complete picture of how students experience curricula,[87] it can still account for some differences in student achievement. TIMSS 2027 collects information about whether students have been taught the mathematics and science topics included in the TIMSS assessment in the Teacher Questionnaire.

Homework

Assignment of homework in mathematics and science varies both within and across countries. 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.[88,89] Teachers may assign homework for different purposes, including practicing skills taught in class or previewing topics in upcoming lessons.[90] TIMSS 2027 collects information about the purposes of mathematics and science homework in the Teacher Questionnaire.

Information Technology

Computer Use During Instruction

Within and across countries, schools and classrooms vary in access to devices such as computers and tablets, although use of digital devices in classrooms has increased over time, especially following the COVID-19 pandemic. Over the 2015, 2019, and 2023 cycles, TIMSS data have shown a steady increase in the percentage of students whose mathematics and science teachers report that students have access to digital devices during instruction. Some research has shown that performing classroom activities, such as notetaking on computers is associated with lower achievement than doing so on paper.[91] Much of the research in this area is focused on university-level students, although there is also some support that taking notes on paper is associated with improved conceptual understanding in science for younger students.[92] TIMSS 2027 collects information about whether students use computers or paper-and-pencil more often for routine classroom activities in the Teacher Questionnaire.

Use of Generative Artificial Intelligence Tools

Generative artificial intelligence is a rapidly evolving field, and it is not possible to make definitive claims about its impact on student learning in mathematics and science. However, there is evidence that teachers use artificial intelligence for a variety of purposes.[93,94] TIMSS 2027 collects information about teacher use of generative artificial intelligence for teaching-related activities in the Teacher Questionnaire.

Classroom Climate and Instructional Quality

Instructional Clarity and Supportive Classroom

Instructional clarity and a supportive classroom environment are two concepts that relate to students' perceptions of their teachers' instructional strategies and are important components of instructional quality. 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.[95,96] Teachers who establish a supportive classroom environment engage in practices such as providing helpful feedback, clearly addressing student questions, and encouraging struggling students.[97] Several studies using TIMSS data related to these topics from previous cycles have found positive associations between instructional clarity and student achievement.[98,99,100] There is also some for a positive association between a supportive classroom climate and student achievement.[101] TIMSS 2027 collects information about students' perceptions of instructional clarity and supportive classroom climate in the Student Questionnaire.

Cognitive Activation

Cognitive activation is another important component of instructional quality and refers to the degree to which students are appropriately challenged during mathematics or science lessons.[102] These challenges can include activities such as explaining answers to questions, using knowledge in new situations, and applying mathematics or science knowledge to solve everyday problems. TIMSS 2027 collects information about the frequency of cognitively challenging activities in mathematics and science lessons in the Student and Teacher Questionnaires.

Classroom Disruptions

Classroom disruptions can be detrimental to student learning, as they reduce time spent on curricular content and negatively affect the classroom climate. Classroom management refers to non-instructional procedures put in place by teachers that promote student learning and discourage disruptive behavior and is an important component of instructional quality.[103,104] Direct links between classroom management, disruptive behavior, and student achievement are difficult to establish, but some research suggests that effective classroom management is positively related to student achievement.[105,106,107] TIMSS 2027 collects information about students' perceptions of classroom disruptions and management in the Student Questionnaire.

Factors Limiting Instruction

There are various school- and student-level factors that can limit the effectiveness of mathematics or science instruction within the classroom. School-level factors include responsibility for teaching too many students, lack of preparation time, or frequent curriculum changes. Student factors can be directly related to academic preparedness (such as a lack of prerequisite knowledge or skills), well-being (such as lack of basic nutrition or frequent absences), or behavior in the classroom (such as distraction or disruption). These factors can not only limit teachers' abilities to provide effective instruction but may also relate to student achievement. For example, research suggests that students lacking basic nutrition tend to have lower academic achievement.[108,109] Frequent absences limit students' opportunities to learn and participate in mathematics or science lessons, and some research suggests that student absences have increased since the COVID-19 pandemic, although this likely varies across countries.[110] TIMSS 2027 collects information about school- and student-level factors that potentially limit instruction in the Teacher and Student Questionnaires.

Student Characteristics, Attitudes, and Behaviors

Many student-level attributes that may contribute to mathematics and science achievement, including experiences at school and student attitudes towards the subjects. Some attributes, such as liking and valuing mathematics and science, may also be considered independent goals of education. It is important to acknowledge the link between students' attitudes and behaviors; in addition to being related to achievement, these are also likely to be related to each other. TIMSS 2027 collects information about these topics in the Student Questionnaire for both Grades 4 and 8. The topics included in these questionnaires are summarized in Exhibit 5.

Exhibit 5: Summary of Student Characteristics, Attitudes, and Behaviors Topics and Sub-Topics

Topic	Sub-Topic	Questionnaire Grade(s)
Student Demographics		Grade 4 & Grade 8
Student Experiences at School	School Belonging	Grade 4 & Grade 8
	Bullying	Grade 4 & Grade 8
Student Attitudes Toward Mathematics and Science	Liking Mathematics and Science	Grade 4 & Grade 8
	Valuing Mathematics and Science**	Grade 4 & Grade 8
	Confidence in Mathematics and Science	Grade 4 & Grade 8
Student Use of Information and Communications Technology (ICT)	Computer Use for Schoolwork	Grade 4 & Grade 8
	Use of Artificial Intelligence for Schoolwork*	Grade 4 & Grade 8
Students' Environmental Attitudes and Behaviors	Valuing Environmental Preservation	Grade 4 & Grade 8
	Efficacy for and Enactment of Environmentally Responsible Behaviors	Grade 4 & Grade 8

* Indicates a new topic introduced in TIMSS 2027. Topics that are not new may have different items than in previous TIMSS cycles.

** New for Grade 4.

Student Demographics

Information about students' demographic characteristics allows for exploration of achievement gaps between different groups of students. Student gender may be of particular interest for this purpose, as many countries show achievement gaps between boys and girls in mathematics and science.[111] Student age also relates to student achievement: In countries where students enter primary school strictly based on age, older students may have more advanced skills than younger students because of maturation. However, depending on retention policies, older students who have repeated a grade may struggle more academically than their younger peers. TIMSS 2027 collects information about student demographics in the Student Questionnaire.

Student Experiences at School

School Belonging

Students' sense of school belonging has been found to contribute to general well-being and academic achievement.[112,113] Sense of school belonging is shaped by how students perceive themselves and their relationships with others (teachers, other students, etc.) within the school, as well as their relationship with the school community itself.[114] These social connections are an important component of student well-being at school.[115] TIMSS 2027 collects information about students' sense of school belonging in the Student Questionnaire.

Bullying

Bullying involves repeated aggressive behavior intended to intimidate or harm students. Bullying can take a variety of forms and can occur in person or virtually. Individuals who would not bully others in person may be more likely to do so online because of online disinhibition.[116] However, there is an association between experiencing bullying online and in person.[117] Research using data from previous cycles of TIMSS has shown evidence that reports of experiencing frequent bullying is associated with lower academic achievement, and students who report being bullied most frequently have substantially lower achievement than their peers.[118,119] TIMSS 2027 collects information about students' experiences of bullying behaviors in the Student Questionnaire.

Student 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 is a predictor of behavior,[120] and encourages students to pursue a subject they find interesting and enjoy learning.[121,122] Students who report liking mathematics and science tend to have higher achievement and be more likely to choose courses in these subjects later in schooling than those who report lower levels of liking the subjects.[123,124] These relationships can be reciprocal; students who do well in mathematics and science may be more likely to have positive attitudes towards the subjects.[125] TIMSS 2027 collects information about students' liking of mathematics and science in the Student Questionnaire.

Valuing Mathematics and Science

In contrast to intrinsic motivation, extrinsic motivation refers to motivation that is inspired by a separate outcome from the activity itself.[126] Students who are extrinsically motivated to learn mathematics and science may value the subjects because of future opportunities, such as entrance into desirable educational programs or a well-paying career. Students may also be extrinsically motivated by the desire to impress or help others.[127] Some research suggests that such motivation is associated with choosing science courses later in schooling, particularly for students from disadvantaged backgrounds.[128] Additionally, students who articulate an interest in science careers in primary or early secondary school are more likely to actually pursue those careers.[129] TIMSS 2027 collects information about students' valuing of mathematics and science in the Student Questionnaire.

Confidence (Self-Concept) in Mathematics and Science

Self-concept (or confidence, as traditionally named in TIMSS) is domain-specific and relates to how students view their abilities in different subjects.[130] Students' self-appraisal of their abilities in a given subject are often based on past experiences and how they see themselves compared with their peers.[131] Students who are confident in a particular subject persevere through challenging material because they believe they will ultimately succeed.[132] Additionally, anxiety or a lack of confidence in a subject is associated with lower achievement.[133,134] As with liking, confidence and achievement in academic subjects may have a reciprocal relationship. TIMSS 2027 collects information about student confidence in mathematics and science in the Student Questionnaire.

Student Use of Information and Communications Technology (ICT)

Computer Use for Schoolwork

Students vary in their use of computers, both at home and in school.[135] Computers can be used for a variety of school tasks, including writing text, creating presentations, and working with data. TIMSS 2027 collects information about how often students use computers for different school-related tasks in the Student Questionnaire.

Artificial Intelligence Use for Schoolwork

Student use of generative artificial intelligence (AI) for school-related tasks is an area of emerging interest; little is currently known about how frequently students use these types of tools, especially younger students. TIMSS 2027 collects information about how often students use AI for schoolwork in the Student Questionnaire.

Students' Environmental Attitudes and Behaviors

Valuing Environmental Preservation

The degree to which students value the natural environment may relate to their enactment of environmentally responsible behaviors. Valuing environmental preservation is a component of the Theory of Ecological Attitude.[136,137] Valuing environmental preservation reflects a tendency to endorse the conservation and preservation of nature. Students with preservation-oriented attitudes are likely to enjoy spending time in nature and care about the protection of natural areas. TIMSS 2027 collects information about students' attitudes towards environmental preservation in the Student Questionnaire.

Efficacy for and Enactment of Environmentally Responsible Behaviors

Practicing environmentally responsible behaviors is related to many factors, including attitudes, knowledge, and opportunities and circumstances.[138,139] The agency that children have to make consequential decisions, and their ability to exercise control over different aspects of their environments, likely varies across countries, cultures, and households.[140] Action competence is one framework for considering such behaviors and conceptualizes action for sustainable development as being driven by knowledge, willingness, and efficacy to act in solving challenging problems.[141] TIMSS 2027 focuses on the efficacy component of this framework, which emphasizes children's ability to engage in environmentally responsible behaviors. TIMSS 2027 collects

information about students' efficacy to enact environmentally responsible behaviors, as well as whether they engage in the behaviors, in the Student Questionnaire.

National Contexts

Students' families, classrooms, and schools are all situated within broader national contexts. Country-level policies about the organization of the education system and mathematics and science curricula are important contributors to students' experiences and learning. All information about national contexts in TIMSS 2027 is collected in the Curriculum Questionnaire, the general contents of which are summarized in Exhibit 6. This information is also complemented by countries' chapters in the *TIMSS 2027 Encyclopedia*.

Exhibit 6: Summary of National Contexts Topics and Sub-Topics

Topic	Sub-Topic
Organization of Education System	Number of Years of School
	Age of Entry and Retention Policies
	System for Preprimary Education
	Language(s) of Instruction
	Teacher and Principal Preparation
Mathematics and Science Curricula	Curriculum Specifications
	Instructional Materials and Use of Digital Devices
	TIMSS Assessment Topics Covered in the Curriculum

Topics may have different items than in previous TIMSS cycles.

Organization of the Education System

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 the years of education that are nationally mandated and provided.

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.[142] 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.[143,144,145]

System for Preprimary Education

Even before they begin formal primary school, children are exposed 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 suggests that attending preprimary programs relates to positive later academic outcomes and that this relationship depends on the quality of the preprimary program.[146,147,148] The TIMSS Curriculum

Questionnaire gathers information on the different types of early childhood and preprimary education available within countries, which contextualizes the student-level information collected in the Home Questionnaire.

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 information on the most typical preparation routes for teachers and principals within each country.

Mathematics and Science Curricula

Curriculum Specifications

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.[149] 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.

Instructional Materials and Use of Digital Devices

Country policies vary regarding the selection of instructional materials and incorporation of digital devices into mathematics and science instruction. As access to computers continues to increase, many countries' curricula include explicit statements or guidance about their use in mathematics and science instruction.[150]

TIMSS Assessment Topics Covered in the Curriculum

Particular topics and skills are introduced at different points in the mathematics and science curricula of different countries. TIMSS 2027 collects information on countries' coverage of the mathematics and science topics articulated in the TIMSS 2027 Mathematics Framework and TIMSS 2027 Science Framework. Such information is essential for contextualizing the performance of each country's students on the TIMSS assessment.

References

1 Creemers, B. & Kyriakides, L. (2008). *The dynamics of educational effectiveness: A contribution to policy, practice and theory in contemporary schools.* Routledge.

2 Vu, T., Magis-Weinberg, L., Jansen, B. R. J., et al. Motivation-achievement cycles in learning: A literature review and research agenda. *Educational Psychology Review, 34*, 39–71 (2022). https://doi.org/10.1007/s10648-021-09616-7

3 Sachisthal, M. S. M., Jansen, B. R. J., Peetsma, T. T. D., Dalege, J., van der Maas, H. L. J., & Raijmakers, M. E. J. (2019). Introducing a science interest network model to reveal country differences. *Journal of Educational Psychology, 111*(6), 1063–1080. https://doi.org/10.1037/edu0000327

4 Dahl, G. B., & Lochner, L. (2012). The impact of family income on child achievement: Evidence from the earned income tax credit. *American Economic Review*, *102*(5), 1927–1956. https://doi.org/10.1257/aer.102.5.1927

5 Davis-Kean, P. E. (2005). The influence of parent education and family income on child achievement: the indirect role of parental expectations and the home environment. *Journal of Family Psychology, 19*(2), 294–304. https://doi.org/10.1037/0893-3200.19.2.294

6 Sirin, S. R. (2005). Socioeconomic status and academic achievement: A meta-analytic review of research. *Review of Educational Research, 75*(3), 417–453. https://doi.org/10.3102/00346543075003417

7 von Davier, M., Kennedy, A., Reynolds, K., Fishbein, B., Khorramdel, L., Aldrich, C., Bookbinder, A., Bezirham, U., & Yin, L. (2024). *TIMSS 2023 International results in mathematics and science. Boston* College, TIMSS & PIRLS International Study Center. https://doi.org/10.6017/lse.tpisc.timss.rs6460

8 Mullis, I. V. S., Martin, M.O., Foy, P., Kelly, D. L., & Fishbein, B. (2020). TIMSS 2019 international results in mathematics and science. Boston College, TIMSS & PIRLS International Study Center. https://timssandpirls.bc.edu/timss2019/international-results/

9 Chmielewski, A. K. (2019). The global increase in the socioeconomic achievement gap, 1964 to 2015. *American Sociological Review, 84*(3), 517–544. https://doi.org/10.1177/0003122419847165

10 Kim, S., Cho, H., & Kim, L. Y. (2019). Socioeconomic status and academic outcomes in developing countries: a meta-analysis. *Review of Educational Research, 89*(6), 875–916. https://doi.org/10.3102/0034654319877155

11 Avvisati, F. (2020). The measure of socio-economic status in PISA: A review and some suggested improvements. *Large-scale Assessments in Education, 8*(8). https://doi.org/10.1186/s40536-020-00086-x

12 Entorf, H., & Minoiu, N. (2005). What a difference immigration policy makes: A comparison of PISA scores in Europe and traditional countries of immigration. *German Economic Review, 6*(3), 355–376. https://doi.org/10.1111/j.1468-0475.2005.00137.x

13 Robertson, S. & Graven, M. (2019). Language as an including or excluding factor in mathematics teaching and learning. *Mathematics Education Research Journal, 32*, 77–101. https://doi.org/10.1007/s13394-019-00302-0

14 von Davier, Kennedy, Reynolds, Fishbein, Khorramdel, Aldrich, Bookbinder, Bezirham, & Yin, *TIMSS 2023 International results in mathematics and science*.

15 Goodall, J., & Montgomery, C. (2014). Parental involvement to parental engagement: A continuum. Educational Review, 66(4), 399–410. https://doi.org/10.1080/00131911.2013.781576

16 Aldridge, J.M. & McChesney, K. (2021). Parents' and caregivers' perceptions of the school climate: Development and validation of the Parent and Caregiver Survey (PaCS). *Learning Environments Research, 24*, 23–41. https://doi.org/10.1007/s10984-020-09308-z

17 Liu, J., Riesch, S., Tien, J., Lipman, T. Pinto-Martin, J., & O'Sullivan, A. (2022). Screen media overuse and associated physical, cognitive, and emotional/behavioral outcomes in children and adolescents: An integrative review. *Journal of Pediatric Health Care, 36*(2), 99–109. https://doi.org/10.1016/j.pedhc.2021.06.003

18 Skvarc, D. R., Penny, A., Harries, T., Wilson, C., Joshua, N., & Byrne, L. K. (2021). Type of screen time and academic achievement in children from Australia and New Zealand: Interactions with socioeconomic status. *Journal of Children and Media*, *15*(4), 509–525. https://doi.org/10.1080/17482798.2021.1878045

19 Gustafsson, J.-E., Hansen, K. Y., & Rosén, M. (2013). Effects of home background on student achievement in reading, mathematics, and science at the fourth grade. In M. O. Martin & I. V. S. Mullis (Eds.), *TIMSS and PIRLS 2011: Relationships among reading, mathematics, and science achievement at the fourth grade—Implications for early learning* (pp. 181–287). Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College. https://timssandpirls.bc.edu/timsspirls2011/downloads/TP11_Chapter_4.pdf

20 Duncan, G. J., Dowsett, C. J., Claessens, A., Magnuson, K., Huston, A. C., Klebanov, P., Pagani, L. S., Feinstein, L., Engel, M., Brooks-Gunn, J., Sexton, H., Duckworth, K., & Japel, C. (2007). School readiness and later achievement. *Developmental Psychology, 43*(6), 1428–1446. https://doi.org/10.1037/0012-1649.43.6.1428

21 Hart, B., & Risley, T.R. (2003). The early catastrophe: The 30 million word gap by age 3. *American Educator, 27(*1), 4–9. https://www.aft.org/ae/spring2003/hart_risley

22 Zhu, J., & Chiu, M.M. (2019). Early home numeracy activities and later mathematics achievement: early numeracy, interest, and self-efficacy as mediators. *Educational Studies in Mathematics, 102,* 173–191. https://doi.org/10.1007/s10649-019-09906-6

23 Anders, Y., Rossbach, H.G., Weinert, S., Ebert, S., Kuger, S., Lehrl, S., & von Maurice, J. (2012). Home and preschool learning environments and their relations to the development of early numeracy skills. *Early Childhood Research Quarterly*, *27*(2), 231–244. https://doi.org/10.1016/j.ecresq.2011.08.003

24 Claessens, A., & Engel, M. (2013). How important is where you start? Early mathematics knowledge and later school success. *Teachers College Record, 115*, 1–29. https://doi.org/10.1177/016146811311500603

25 von Davier, Kennedy, Reynolds, Fishbein, Khorramdel, Aldrich, Bookbinder, Bezirham, & Yin, *TIMSS 2023 International results in mathematics and science*.

26 Chang, I. (2023). Early numeracy and literacy skills and their influences on fourth-grade mathematics achievement: a moderated mediation model. *Large-scale Assessments in Education, 11*(18). https://doi.org/10.1186/s40536-023-00168-6

27 Mullis, I. V. S., Martin, M. O., & Foy, P. (2013). The impact of reading ability on TIMSS mathematics and science achievement at the fourth grade: An analysis by item reading demands. In M. O. Martin & I. V. S. Mullis (Eds.), *TIMSS and PIRLS 2011: Relationships among reading, mathematics, and science*

achievement at the fourth grade—Implications for early learning (pp. 67–108). Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College. https://timssandpirls.bc.edu/timsspirls2011/downloads/TP11_Chapter_2.pdf

28 Coleman, J. S., Campbell, E. Q., Hobson, C. J., McPartland, J., Mood, A. M., Weinfeld, F. D., & York, R. L. (1966). *Equality of educational opportunity*. National Center for Educational Statistics, US Government Printing Office. https://eric.ed.gov/?id=ED012275

29 Martin, M. O., Foy, P., Mullis, I. V. S., & O'Dwyer, L. M. (2013). Effective schools in reading, mathematics, and science at the fourth grade. In M. O. Martin & I. V. S. Mullis (Eds.), *TIMSS and PIRLS 2011: Relationships among reading, mathematics, and science achievement at the fourth grade—Implications for early learning*. TIMSS & PIRLS International Study Center, Boston College. https://timssandpirls.bc.edu/timsspirls2011/downloads/TP11_Chapter_3.pdf

30 Sirin, Socioeconomic status and academic achievement.

31 Willms, J. D. (2006). *Learning divides: Ten policy questions about the performance and equity of schools and schooling systems.* (UIS Working Paper No. 5). https://uis.unesco.org/sites/default/files/documents/learning-divides-ten-policy-questions-about-the-performance-and-equity-of-schools-and-schooling-systems-06-en_0.pdf

32 Sciffer, M. G., Perry, L. B., & McConney, A. (2022). Does school socioeconomic composition matter more in some countries than others, and if so, why? *Comparative Education, 58*(1), 37–51. https://doi.org/10.1080/03050068.2021.2013045

33 Rowe, E., & Perry, L. B. (2020). Inequalities in the private funding of public schools: parent financial contributions and school socioeconomic status. *Journal of Educational Administration and History, 52*(1), 42–59. https://doi.org/10.1080/00220620.2019.1689234

34 Marcotte, D. E., & Dalane, K. (2019). Socioeconomic segregation and school choice in American public schools. *Educational Researcher, 48*(8), 493–503. https://doi.org/10.3102/0013189X19879714

35 Goldhaber, D., Lavery, L., & Theobald, R. (2015). Uneven playing field? Assessing the teacher quality gap between advantaged and disadvantaged students. *Educational Researcher*, *44*(5), 293–307. https://doi.org/10.3102/0013189X15592622

36 Lacoe, J. (2020). Too scared to learn? The academic consequences of feeling unsafe in the classroom. *Urban Education, 55*(10), 1385–1418. https://doi.org/10.1177/0042085916674059

37 Thapa, A., Cohen, J., Guffey, S., & Higgins-D'Alessandro, A. (2013). A review of school climate research. *Review of Educational Research, 83*(3), 357–385. https://doi.org/10.3102/0034654313483907

38 Konishi, C., Hymel, S., Zumbo, B. D., & Li, Z. (2010). Do school bullying and student-teacher relationships matter for academic achievement? A multilevel analysis. *Canadian Journal of School Psychology, 25*(1), 19–39. https://psycnet.apa.org/doi/10.1177/0829573509357550

39 Kutsyuruba, B., Klinger, D.A., & Hussain, A. (2015). Relationships among school climate, school safety, and student achievement and well-being: A review of the literature. *Review of Education*, *3*(2), 103–135. https://doi.org/10.1002/rev3.3043

40 Gottfredson, G.D., Gottfredson, D.C., Payne, A.A., & Gottfredson, N.C. (2005). School climate predictors of school disorder: Results from a national study of delinquency prevention in schools. *Journal of Research in Crime and Delinquency, 42*(4), 412–444. https://psycnet.apa.org/doi/10.1177/0022427804271931

41 Thapa, Cohen, Guffey, & Higgins-D'Alessandro, A review of school climate research.

42 Hoy, W.K. (2012). School characteristics that make a difference for the achievement of all students: a 40-year odyssey. *Journal of Educational Administration, 50*(1), 76–97.

43 Nilsen, T., & Gustafsson, J.-E. (2014). School emphasis on academic success: Exploring changes in science performance in Norway between 2007 and 2011 employing two-level SEM. *Educational Research and Evaluation, 20*(4), 308–327. https://doi.org/10.1080/13803611.2014.941371

44 Hoy, W.K., Tarter, C.J., & Hoy, A.W. (2006). Academic optimism of schools: A force for student achievement. *American Educational Research Journal, 43*(3), 425–446. https://www.jstor.org/stable/4121765

45 Wu, J.H., Hoy, W.K., & Tarter, C.J. (2013). Enabling school structure, collective responsibility, and a culture of academic optimism: Toward a robust model of school performance in Taiwan. *Journal of Educational Administration, 51*(2), 176–193. https://doi.org/10.1108/09578231311304698

46 Harrison, M. G., King, .R B., & Wang, H. (2023). Satisfied teachers are good teachers: The association between teacher job satisfaction and instructional quality. *British Educational Research Journal, 49*(3), 476–498. https://doi.org/10.1002/berj.3851

47 Johnson, S.M., Kraft, M.A., & Papay, J.P. (2012). How context matters in high-need schools: The effects of teachers' working conditions on their professional satisfaction and their students' achievement. *Teachers College Record*, *114*(10), 1–39. http://dx.doi.org/10.1177/016146811211401004

48 Cohen, J., McCabe, L., Michelli, N.M., & Pickeral, T. (2009). School climate: Research, policy, practice, and teacher education. *Teachers College Record, 111*(1), 190–213. https://doi.org/10.1177/016146810911100108

49 Glewwe, P.W., Hanushek, E.A., Humpage, S.D., & Ravina, R. (2011). School resources and educational outcomes in developing countries: A review of the literature from 1990 to 2010. In P. Glewwe (Ed.), *Education policy in developing countries* (pp. 13–64). Chicago: University of Chicago Press.

50 Hanushek, E.A., & Wößmann, L. (2017). School resources and student achievement: A review of cross-country economic research. In M. Rosén, K.Y. Hansen, & U. Wolff (Eds.), *Cognitive abilities and educational outcomes* (pp. 149–171). Methodology of Educational Measurement and Assessment. Switzerland: Springer International Publishing. https://doi.org/10.1007/978-3-319-43473-5_8

51 Higgs, A. L., & McMillan, V. M. (2006). Teaching through modeling: Four schools' experiences in sustainability education. *The Journal of Environmental Education, 38*(1), 39–53. https://doi.org/10.3200/JOEE.38.1.39-53

52 Uitto, A., Boeve-de Pauw, J., & Saloranta, S. (2015). Participatory school experiences as facilitators for adolescents' ecological behavior. *Journal of Environmental Psychology, 43*, 55–65. https://doi.org/10.1016/j.jenvp.2015.05.007

53 Breiting, S., Mayer, M., & Mogensen, F. (2005). *Quality criteria for ESD-Schools*. Austrian Federal Ministry of Education, Science and Culture. https://www.researchgate.net/publication/283485687_Quality_Criteria_for_ESD_Schools_Engaging_Whole_Schools_in_Education_for_Sustainable_Development

54 Mathar, R. (2015). A whole school approach to sustainable development: Elements of education for sustainable development and students' competencies for sustainable development. In R. Jucker & R. Mathar (Eds.), *Schooling for sustainable development in Europe: Concepts, policies and educational*

experiences at the end of the UN Decade of Education for Sustainable Development (pp. 15–30). Springer International Publishing. https://doi.org/10.1007/978-3-319-09549-3_2

55 Verhelst, D., Vanhoof, J., Van Petegem, P. (2021). School effectiveness for education for sustainable development (ESD): What characterizes an ESD-effective school organization? *Educational Management Administration & Leadership*, *51*(2). https://doi.org/10.1177/1741143220985196

56 Higgs & McMillan, Four schools' experiences in sustainability education.

57 Mathar, Whole school approach to sustainable development.

58 GEM Report UNESCO. (2023). *global education monitoring report 2023: Technology in education: A tool on whose terms?* (1st ed.). GEM Report UNESCO. https://doi.org/10.54676/UZQV8501

59 Gerick, J., Eickelmann, B., & Bos, W. (2017). School-level predictors for the use of ICT in schools and students' CIL in international comparison. *Large-scale Assessments in Education, 5*(1), 1–13. https://doi.org/10.1186/s40536-017-0037-7

60 Thomas, K. M., O'Bannon, B. W., & Britt, V. G. (2014). Standing in the schoolhouse door: Teacher perceptions of mobile phones in the classroom. *Journal of Research on Technology in Education*, *46*(4), 373–395. https://doi.org/10.1080/15391523.2014.925686

61 Goddard, R., Goddard, Y., Kim, S.E., & Miller, R. (2015). A theoretical and empirical analysis of the roles of instructional leadership, teacher collaboration, and collective efficacy beliefs in support of student learning. *American Journal of Education*, *121*(4), 501–530. https://doi.org/10.1086/681925

62 Tschannen-Moran, M., & Gareis, C. (2015). Faculty trust in the principal: An essential ingredient in high-performing schools. *Journal of Educational Administration, 53*(1), 66–92. https://eric.ed.gov/?id=EJ1054239

63 Jung, S. B. & Sheldon, S. (2020). Connecting dimensions of school leadership for partnerships with school and teacher practices of family engagement. *School Community Journal*, *30*(1), 9–32. https://eric.ed.gov/?id=EJ1257579

64 Darling-Hammond, L. (2000). How teacher education matters. *Journal of Teacher Education, 51*(3), 166–173. https://doi.org/10.1177/0022487100051003002

65 Wedel, K. (2021). Instruction time and student achievement: The moderating role of teacher qualifications. *Economics of Education Review, 85*. https://doi.org/10.1016/j.econedurev.2021.102183

66 Hill, H.C., Rowan, B., & Ball, D.L. (2005). Effects of teachers' mathematical knowledge for teaching on student achievement. *American Educational Research Journal, 42*(2), 371–406. https://doi.org/10.3102/00028312042002371

67 Harris, D.N., & Sass, T.R. (2011). Teacher training, teacher quality and student achievement. *Journal of Public Economics, 95*(7–8), 798–812. https://doi.org/10.1016/j.jpubeco.2010.11.009

68 Ladd, H.F., & Sorensen, L.C. (2017). Returns to teacher experience: Student achievement and motivation in middle school. *Education Finance and Policy*, *12*(2), 241–279. https://eric.ed.gov/?id=ED618278

69 Reynolds, K. A., Aldrich, C. E. A., Bookbinder, A., Gallo, A., von Davier, M., & Kennedy, A. (Eds.) (2024). *TIMSS 2023 encyclopedia: Education policy and curriculum in mathematics and science.* Boston College, TIMSS & PIRLS International Study Center. https://doi.org/10.6017/lse.tpisc.timss.rs5882

70 Van Driel, J.H. & Berry, A. (2010). Pedagogical content knowledge. In P. Peterson, E. Baker, & B. McGaw (Eds.), *International Encyclopedia of Education* (3rd ed, pp. 656–661). Elsevier.

71 Hanushek & Wößmann, School resources and student achievement.

72 Mullis, I. V. S., Martin, M. O., & Loveless, T. (2016). *20 years of TIMSS: International trends in mathematics and science achievement, curriculum, and instruction*. Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College. https://timssandpirls.bc.edu/timss2015/international-results/timss2015/wp-content/uploads/2016/T15-20-years-of-TIMSS.pdf

73 Wedel, Instruction time and student achievement.

74 Kim, Y. (2018). Revisiting classroom practices in East Asian countries: examination of within-country variations and effects of classroom instruction. *Teachers College Record, 120*(7), 1–42. https://doi.org/10.1177/016146811812000706

75 Lehtinen, E., Hannula-Sormunen, M., McMullen, J., & Gruber, H. (2017). Cultivating mathematical skills: from drill-and-practice to deliberate practice*. ZDM Mathematics Education, 49*, 625–636. https://doi.org/10.1007/s11858-017-0856-6

76 Rittle-Johnson, B., Loehr, A. M., & Durkin, K. (2017). Promoting self-explanation to improve mathematics learning: a meta-analysis and instructional design principles. *ZDM Mathematics Education, 49*, 599–611. https://doi.org/10.1007/s11858-017-0834-z

77 Stickney, E. M., Sharp, L. B., & Kenyon, A. S. (2012). Technology-enhanced assessment of math fact automaticity: Patterns of performance for low- and typically achieving students. *Assessment for Effective Intervention, 37*(2), 84–94. https://eric.ed.gov/?id=EJ955510

78 Wong, M. & Evans, D. (2007). Improving basic multiplication fact recall for primary school students. *Mathematics Education Research Journal, 19*(1), 89–106. https://eric.ed.gov/?id=EJ776257

79 Arnold, J. C., Kremer, K., & Mayer, J. (2014). Understanding students' experiments—What kind of support do they need in inquiry tasks? *International Journal of Science Education, 36*(16), 2719–2749. https://doi.org/10.1080/09500693.2014.930209

80 Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: an analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist, 41*(2), 75–86. https://doi.org/10.1207/s15326985ep4102_1

81 Furtak, E. M., Seidel, T., Iverson, H., & Briggs, D. C. (2012). Experimental and quasi-experimental studies of inquiry-base science teaching: A meta-analysis. *Review of Educational Research, 82*(3), 300–329. https://doi.org/10.3102/0034654312457206

82 Teig, N., Scerer, R., & Nilsen, T. (2018). More isn't always better: The curvilinear relationship between inquiry-based teaching and student achievement in science. *Learning and Instruction, 56*, 20–29. https://doi.org/10.1016/j.learninstruc.2018.02.006

83 Rönnebeck, S. Bernholt, S., & Rophol, M. (2016). Searching for common ground—A literature review of empirical research in scientific inquiry activities. *Studies in Science Education, 52(*2), 161–197. https://doi.org/10.1080/03057267.2016.1206351

84 Boeve-de Pauw, J., Gericke, N., Olsson, D., & Berglund, T. (2015). The effectiveness of education for sustainable development. *Sustainability, 7*(11), 15693–15717. https://doi.org/10.3390/su71115693

85 Sass, W., Claes, E., Boever-de Pauw, J., De Maeyer, S., Schelfhout, W., Van Petegem, P., & Isac, M. M. (2022). Measuring professional action competence in education for sustainable development (PACesd). *Environmental Education Research, 28*(2), 260–275. https://doi.org/10.1080/13504622.2021.1976731

86 Floden, R. E. (2002). The measurement of opportunity to learn. In Porter, A.C. & Gamoran, A. (Eds.), *Methodological advances in crossnational surveys of educational achievement.* Washington, DC: National Academy Press.

87 Dougherty, K. J. (1996). Opportunity-to-learn standards: A sociological critique. *Sociology of Education*, 69, pp. 40–65. https://doi.org/10.2307/3108455

88 Fan, H., Xu, J., Cai, Z., He., & Fan, X. (2017). Homework and students' achievement in math and science: A 30-year meta-analysis, 1986-2015*. Educational Research Review, 20*, 35–54. https://doi.org/10.1016/j.edurev.2016.11.003

89 Fernández-Alonso, R., Álvarez-Diaz, M., Suárez-Álvarez, J., & Muñiz, J. (2017). Students' achievement and homework assignment strategies. *Frontiers in Psychology, 8*, 1–11. https://doi.org/10.3389/fpsyg.2017.00286

90 Cooper, H. M (2001). *The battle over homework: Common ground for administrators, teachers, and parents* (2nd ed.), Sage Publications, Thousand Oaks, CA.

91 Flanigan, A.E., Kiewra, K.A., Lu, J. & Dzhuraev, D. (2023). Computer versus longhand note taking: Influence of revision. *Instructional Science, 51*. https://doi.org/10.1007/s11251-022-09605-5

92 Horbury, S.R. &Edmonds, C.J. (2021). Taking class notes by hand compared to typing: Effects on children's recall and understanding. *Journal of Research in Childhood Education, 35*. https://doi.org/10.1080/02568543.2020.1781307

93 Kavitha, K. & Joshith, V.P. (2024). Pedagogical incorporation of artificial intelligence in K-12 science education: A decadal bibliometric mapping and systematic literature review (2013-2023). *Journal of Pedagogical Research, 8(*4), 437–465. https://doi.org/10.33902/JPR.202429218

94 Heeg, D.M. & Avraamidou, L. (2023). The use of artificial intelligence in school science: A systematic literature review. *Educational Media International, 60(*2), 125–150. https://doi.org/10.1080/09523987.2023.2264990

95 Ferguson, R.F. (2012). Can student surveys measure teaching quality? *Phi Delta Kappan*, *94*(3), 24–28. https://doi.org/10.1177/003172171209400306

96 Lipowsky, F., Rakoczy, K., Pauli, C., Drollinger-Vetter, B., Klieme, E., & Reusser, K. (2009). Quality of geometry instruction and its short-term impact on students' understanding of the Pythagorean Theorem. *Learning and Instruction*, *19*, 527–537. https://doi.org/10.1016/j.learninstruc.2008.11.001

97 Nilsen, T., Gustafsson, J.-E., & Blömeke, S. (2016). Conceptual framework and methodology of this report. In T. Nilsen & J.-E. Gustafsson (Eds.), *Teacher quality, instructional quality, student outcomes* (pp. 1–19). Amsterdam, The Netherlands: IEA. https://doi.org/10.1007/978-3-319-41252-8_1

98 Asp, L., Klapp, A., & Rosén, M. (2025). Does teaching quality matter for Nordic primary school students' mathematics confidence and mathematics achievement? A multilevel structure equational analysis of Nordic TIMSS 2019 grade 4 data. *Large-scale Assessments in Education, 13*(7). https://doi.org/10.1186/s40536-025-00238-x

99 Blömeke, S. & Olsen, R. V. (2019). Consistency of results regarding teacher effects across subjects, school levels, outcomes, and countries. *Teaching and Teacher Education, 77*, 170–182. https://doi.org/10.1016/j.tate.2018.09.018

100 Teig & Luoto, Teaching quality and assessment practice.

101 Klieme, E. & Nilsen, T. (2022). Teaching quality and student outcomes in TIMSS and PISA. In T. Nilsen, A. Stancel-Piątak, J. E. Gustafsson (Eds.), International Handbook of Comparative Large-Scale Studies in Education. Springer, Cham. https://doi.org/10.1007/978-3-030-88178-8_37

102 Praetorius, A. K., Klieme, E., Herbert, B., & Pinger, P. (2018). Generic dimensions of teaching quality: The German framework of three basic dimensions. *ZDM–Mathematics Education, 50*(3), 407–426. https://doi.org/10.1007/s11858-018-0918-4

103 Nilsen, Gustafsson, & Blömeke, S. Conceptual framework and methodology of this report.

104 Oliver, R.M., Wehby, J.H., & Reschly, D.J. (2011). Teacher classroom management practices: effects on disruptive or aggressive student behavior. *Campbell Systematic Reviews, 7*, 1–55. https://doi.org/10.4073/csr.2011.4

105 Herman, K.C., Reinke, W.M., Dong, N., & Bradshaw, C.P. (2020). Can effective classroom behavior management increase student achievement in middle school? Findings from a group randomized trial. *Journal of Educational Psychology.* Advance online publication. http://dx.doi.org/10.1037/edu0000641

106 Van Dijk, W., Gage, N.A., & Grasley-Boy, N. (2019). The relation between classroom management and mathematics achievement: a multilevel structural equation model. *Psychology in the Schools, 56*, 1173–1186. https://doi.org/10.1002/pits.22254

107 Teig, N. & Luoto, J.M. (2024). Teaching quality and assessment practice: Trends over time and correlation with achievement. In: Teig, N., Nilsen, T., Yang Hansen, K. (Eds.). *Effective and equitable teacher practice in mathematics and science education.* IEA Research for Education, vol 14. Springer, Cham. https://doi.org/10.1007/978-3-031-49580-9_5

108 Faught, E.L., Williams, P.L., Willows, N.D., Asbridge, M., & Veugelers, P.J. (2017). The association between food insecurity and academic achievement in Canadian school-aged children. *Public Health Nutrition, 20*(15), 2778–2785.

109 Taras, H. (2005). Nutrition and performance at school. *Journal of School Health, 75*(6), 199–213. https://doi.org/10.1111/j.1746-1561.2005.00025.x

110 Dee, T. S. (2024). Higher chronic absenteeism threatens academic recovery from the COVID-19 pandemic. *Proceedings of the National Academy of Sciences, 121*(3). https://doi.org/10.1073/pnas.2312249121

111 von Davier, Kennedy, Reynolds, Fishbein, Khorramdel, Aldrich, Bookbinder, Bezirham, & Yin, *TIMSS 2023 International results in mathematics and science.*

112 Korpershoek, H., Canrinus, E. T., Fokkens-Bruinsma, & de Boer, H. (2020). The relationship between school belonging and students' motivational, social-emotional, behavioural, and academic outcomes in secondary education: A meta-analytic review. *Research Papers in Education, 35*(6), 641–680. https://doi.org/10.1080/02671522.2019.1615116

113 Renshaw, T. L., Long, A. C. J., & Cook, C. R. (2015). Assessing adolescents' positive psychological functioning at school: Development and validation of the student subjective wellbeing questionnaire. *School Psychology Quarterly*, *30*(4), 534–552. https://doi.org/10.1037/spq0000088

114 Abubakar, A., van de Vijver, F. J. R., Alonso-Arbiol, I., Suryani, A. O., Pandia, W. S., Handani, P., Arasa, J., Mazrui, L., & Murugumi, M. (2016). Assessing sense of school belonging across cultural contexts using the PSSM: Measurement and functional invariance. *Journal of Psychoeducational Assessment, 34*(4), 380–388. https://doi.org/10.1177/0734282915607161

115 Kleinkorres, R., Stang, J., & McElvany, N. (2020). A longitudinal analysis of reciprocal relations between students' wellbeing and academic achievement. *Journal for Educational Research Online, 20*(2), 114–165. https://doi.org/10.25656/01:20975

116 Wang, L., Jiang, S., Zhou, Z., Fei, W., & Wang, W. (2024). Online disinhibition and adolescent cyberbullying: A systematic review. *Children and Youth Services Review, 156*, https://doi.org/10.1016/j.childyouth.2023.107352

117 Kreski, N. T., Chen, Q., Olfson, M., Cerda, M., Martins, S. S., Mauro, P. M., Branas, C. C. Rajan, S., & Keyes, K.M. (2022). Experiences of online bullying and offline violence-related behaviors among a nationally representative sample of US adolescents, 2011-2019. *Journal of School Health, 92*(4). 376–386. https://doi.org/10.1111/josh.13144

118 Ozyildirim, G. & Karadağ, E. (2024). The effect of peer bullying on academic achievement: A meta-analysis student related to results of TIMSS and PIRLS. *Psychology in the Schools, 61*(5), 2185–2203. https://doi.org/10.1002/pits.23159

119 von Davier, Kennedy, Reynolds, Fishbein, Khorramdel, Aldrich, Bookbinder, Bezirham, & Yin, *TIMSS 2023 International results in mathematics and science.*

120 Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior*. New York: Plenum Press.

121 Fiorella, L., Yoon, S. Y., Atit, K., Power, J. R., Panther, G., Sorby, S., Uttal, D. H. & Veurink, N. (2021). Validation of the Mathematics Motivation Questionnaire (MMQ) for secondary school students. *International Journal of STEM Education, 8,* Article 52. https://doi.org/10.1186/s40594-021-00307-x

122 Bosch, C. (2024). Assessing the psychometric properties of the intrinsic motivation inventory in blended learning environments. *Journal of Education and E-Learning Research, 11*(2), 263–271. https://doi.org/10.20448/jeelr.v11i2.5468

123 Kennedy, J., Quinn, F., & Lyons, T. (2020). The keys to STEM: Australian year 7 students' attitudes and intentions towards science, mathematics and technology courses. *Research in Science Education, 50*, 1805–1832. https://doi.org/10.1007/s11165-018-9754-3

124 Raccanello, D., Brondino, M., Moé, A., Stupnisky, R., & Lichtenfeld, S. (2019). Enjoyment, boredom, anxiety in elementary schools in two domains: Relations with achievement. *The Journal of Experimental Education, 87*(3), 449–469. https://doi.org/10.1080/00220973.2018.1448747

125 Vu, T., Magis-Weinberg, L., Jansen, B. R. J., et al. (2022). Motivation-achievement cycles in learning: A literature review and research agenda. *Educational Psychology Review, 34*, 39–71. https://doi.org/10.1007/s10648-021-09616-7

126 Ryan, R. M. & Deci, E. L. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology, 25*, 54–67. https://doi.org/10.1006/ceps.1999.1020

127 Liang, B., White, A., DeSilva Mousseau, A. M., Hasse, A., Knight, L., Berado, D. & Lund, T. J. (2017). The four P's of purpose among College Bound students: People, propensity, passion, prosocial benefits. *The Journal of Positive Psychology, 12*(3), 281–294. https://doi.org/10.1080/17439760.2016.1225118

128 Mujtaba, T., Sheldrake, R., Reiss, M. J., & Simon, S. (2018). Students' science attitudes, beliefs, and context: Associations with science and chemistry aspirations. *International Journal of Science Education, 40*(6), 644–667. https://doi.org/10.1080/09500693.2018.1433896

129 Tai, R. H., Liu, C .Q., Maltese, A. V., & Fan, X. (2006). Planning early for careers in science. *Science, 312*, 1143–1144. https://doi.org/10.1126/science.1128690

130 Eklöf, H. (2022). Student motivation and self-beliefs. In Nilsen, T., Stancel-Piątak, A., Gustafsson, JE. (eds) *International handbook of comparative large-scale studies in education*. Springer International Handbooks of Education. Springer, Cham. https://doi.org/10.1007/978-3-030-88178-8_44

131 Marsh, H. W., & Craven, R. G. (2006). Reciprocal effects of self-concept and performance from a multidimensional perspective: Beyond seductive pleasure and unidimensional perspectives. *Perspectives on Psychological Science, 1*(2), 133–163. https://doi.org/10.1111/j.1745-6916.2006.00010.x

132 Bandura, A. (1997). *Self-efficacy: The exercise of control.* New York: W. H. Freeman and Company.

133 Namkung, J.M., Peng, P., & Lin, X. (2019). The relation between mathematics anxiety and mathematics performance among school-aged students: A meta-analysis. *Review of Educational Research, 89*(3), 459–496. https://www.jstor.org/stable/45277280

134 Raccanello, Brondino, Moé, Stupnisky, & Lichtenfeld, Enjoyment, boredom, anxiety in elementary schools.

135 Fraillion, J. (Ed.) (2025). *An international perspective on digital literacy: Results from ICILS 2023 (revised)*. International Association for the Evaluation of Educational Achievement (IEA). https://www.iea.nl/sites/default/files/2025-03/ICILS_2023_International_Report.pdf

136 Bogner, F. X. & Wiseman, M. (1999). Toward measuring adolescent environmental perception. *European Psychologist, 4*(3), 139–151. https://doi.org/10.1027//1016-9040.4.3.139

137 Wiseman, M., & Bogner, F. X. (2003). A higher-order model of ecological values and its relationship to personality. *Personality and Individual Differences, 34*(5), 783–794. https://doi.org/10.1016/S0191-8869(02)00071-5

138 Kollmuss, A., & Agyeman, J. (2002). Mind the Gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? *Environmental Education Research, 8*(3), 239–260. https://doi.org/10.1080/13504620220145401

139 Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*(2), 179–211. https://doi.org/10.1016/0749-5978(91)90020-T

140 Uitto, Boeve-de Pauw, & Saloranta, School experiences as facilitators ecological behavior.

141 Sass, W., J. Boeve-de Pauw, D. Olsson, N. Gericke, S. De Maeyer, and Van Petegem, P. (2020). Redefining action competence: The case of sustainable development. *The Journal of Environmental Education, 51*(4), 292–305. https://doi.org/10.1080/00958964.2020.1765132

142 Martin, M. O., Mullis, I. V. S., & Foy, P. (2011). Age distribution and reading achievement configurations among fourth-grade students in PIRLS 2006. *IERI Monograph Series: Issues and Methodologies in Large-scale Assessments, 4*, 9–33. https://ierinstitute.org/fileadmin/Documents/IERI_Monograph/Volume_4/IERI_Monograph_Volume_04_Chapter_1.pdf

143 García-Pérez, J., Hidalgo-Hidalgo, M., & Robles-Zurita, J. A. (2014). Does grade retention affect students' achievement? Some evidence from Spain. *Applied Economics*, *46*(12), 1372–1392. https://doi.org/10.1080/00036846.2013.872761

144 Kretschmann, J., Vock, M., Lüdtke, O., Jansen, M., & Gronostaj, A. (2019). Effects of grade retention on students' motivation: A longitudinal study over 3 years of secondary school. *Journal of Educational Psychology, 111*(8), 1432–1446. https://psycnet.apa.org/doi/10.1037/edu0000353

145 Mathys, C., Véronneau, M., & Lecocq, A. (2019). Grade retention at the transition to secondary school: using propensity score matching to identify consequences on psychosocial adjustment. *Journal of Early Adolescence, 39*(1), 97–133. https://doi.org/10.1177/0272431617735651

146 Broekhuizen, M. L., Mokrova, I. L., Burchinal, M. R., & Garrett-Peters, P. T. (2016). Classroom quality at pre-kindergarten and kindergarten and children's social skills and behavior problems. *Early Childhood Research Quarterly*, *36*, 212–222. https://doi.org/10.1016/j.ecresq.2016.01.005

147 Mashburn, A. J., Pianta, R.C., Hamre, B. K., Downer, J. T., Barbarin, O. A., Bryant, D., Burchinal, M., Early, D. M., & Howes, C. (2008). Measures of classroom quality in prekindergarten and children's development of academic, language, and social skills. *Child Development, 79*(3), 732–749. https://doi.org/10.1111/j.1467-8624.2008.01154.x

148 Duncan, G. J. & Magnuson, K. (2013). Investing in preschool programs. *Journal of Economic Perspectives, 27*(2), 109–132. http://doi.org/10.1257/jep.27.2.109

149 Stacey, O., De Lazzari, G., Grayson, H., Griffin, H., Jones, E., Taylor, A., & Thomas, D. (2018). The globalization of science curricula. *IEA research for education: A series of in-depth analyses based on data of the International Association for the Evaluation of Educational Achievement (IEA)* (Vol. 3). Springer, Cham. https://doi.org/10.1007/978-3-319-71532-2

150 Reynolds, Aldrich, Bookbinder, Gallo, von Davier, & Kennedy, *TIMSS 2023 encyclopedia.*