TRENDS IN INTERNATIONAL MATHEMATICS AND SCIENCE STUDY

TIMSS

TIMSS 2011 Encyclopedia

Education Policy and Curriculum in Mathematics and Science

Volume 2: L–Z and Benchmarking Participants

Edited by:

Ina V.S. Mullis, Michael O. Martin, Chad A. Minnich, Gabrielle M. Stanco, Alka Arora, Victoria A.S. Centurino, and Courtney E. Castle

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Lebanon

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Educational Center for Research and Development
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Introduction

Overview of the Education System

The education system in Lebanon is centralized, with the Ministry of Education and Higher Education regulating all educational institutes in the public sector. However, schools are not regulated directly; regional education bureaus at the center of each province monitor public schools within the province and serve as liaisons between the public school and the directorates of education at the ministry's headquarters in Beirut. Decisions are conveyed to these directorates and then circulated to the schools. Private schools, however, have their own organization, though they are still subject to the authority of the ministry with regard to educational decisions.

The Educational Center for Research and Development (ECRD) is an autonomous administrative organization under the trusteeship of the Ministry of Education and Higher Education. ECRD's tasks include drafting academic and vocational curricula for the pre-university education stage, conducting any revisions and modifications as needed, and preparing all means and ways for applying these curricula, including required teaching methodologies. ECRD prepares the curricula in all subject areas, including mathematics and science, provides teacher training, writes textbooks, and conducts evaluations. ECRD also conducts educational research and secures training for pre-university teachers.

The current structure of the education system in Lebanon divides pre-university education into three stages:

- Kindergarten (ages 5–6);
- Basic Education—Primary level (Cycle 1, Grades 1–3; and Cycle 2, Grades 4–6), and intermediate level (Cycle 3, Grades 7–9); and
- Secondary Education—Secondary level (Cycle 4, Grades 10–12).

Schooling in Lebanon is compulsory through Grade 6 (i.e., kindergarten plus the 6 years of primary education). Private schools usually include all pre-university grade levels (kindergarten, basic education, and secondary education). Some public schools only have basic education grades, while others also include kindergartens. Most public schools include secondary education grades.

Public schools are financed by the Ministry of Education and Higher Education, while private schools receive funding through student fees. However, the processes involved in drafting and modifying curricula and providing teacher education are financed mainly by nongovernmental organizations, private companies, or international bodies, including the United Nations Development Programme and the World Bank.

The Lebanese curriculum is used at all schools in Lebanon, whether public or private. If a school wishes to implement a foreign curriculum (e.g., French, English, or international), the school must implement both Lebanese and foreign programs at the same time.

Languages of Instruction

Mathematics and science instruction in public and private schools is conducted in Arabic throughout the first and second cycles of basic education, though these subjects also may be taught in a foreign language (e.g., French or English). In the third cycle, instruction in mathematics and science is conducted in a foreign language (French or English).

Mathematics Curriculum in Primary and Lower Secondary Grades

The curriculum assures that students who complete Cycle 2 of basic education (Grades 4–6) have the necessary skills and a solid foundation in mathematics. Thus, students must be able to do the following in the mathematical domains described below: [1]

- Mathematical Reasoning—Find patterns in a sequence and generalize them; extract general statements from specific contexts; and argue by providing an analogy and giving examples and counter-examples.
- Problem Solving—Visualize situations and handle information; use and apply mathematics in various domains, especially in technology; verify results; and use calculators to carry out the four arithmetic operations.
- Communication—Read, understand, and interpret a mathematical text by translating it into figures, representations, or equations; and translate a given mathematical relation into spoken language.

- Spatial—Represent locations on a map; characterize various plane (two-dimensional) figures and use geometric instruments to represent them; and develop an understanding of some solid (three-dimensional) figures.
- Numerical—Master the Indo-Arabic system of numeration; recognize decimal numbers; master all types of calculation, including mental; learn to use a calculator (for integers and decimals); and perform simple operations with fractions, and estimate results.
- Measurement—Measure perimeters, areas, volumes, and angles; and use metric units.
- Statistics—Collect and interpret data.

Exhibit 1 presents a summary of the mathematics concepts and skills to be covered in Grade 4 (Cycle 2 of basic education).

Exhibit 1: Mathematics Content in Basic Education, Grade 4

Content Area	Main Topics	Concepts and Skills Covered
Arithmetic and Algebra	Numbers	Natural numbers Integers Fractions Decimals
	Operations	Addition Subtraction Multiplication Division
Geometry	Location	Distance from a point to a straight line Location of a point on a square grid
	Solid Figures	Building models
	Plane Figures	Intersecting lines and parallel lines Classification of quadrilaterals according to their sides Circles and discs
	Transformations	Drawing symmetrical figures with respect to an axis
Measurement	Length	Metric units of length
	Mass	Metric units of mass
	Area	Comparison of areas
	Angles	
	Volume	Liter and its submultiples
Statistics	Handling Data	Collecting and organizing data

In Cycle 3 of basic education (Grades 7–9), students must be able to do the following in the mathematical domains described below: [2]

- Mathematical Reasoning—Find connections between the real world and mathematical models, and between these models and concepts; find the generating formula of a sequence; write simple proofs; and recognize an incorrect proof.
- Problem Solving—Analyze a situation and deduce the relevant elements; look for necessary information to clarify an incomplete set of information; construct a mathematical model associated with a situation; choose a strategy to find a solution; deconstruct a problem into simpler tasks, and (conversely) combine necessary facts to reach a conclusion; and use a calculator.
- Communication—Read, understand, and use mathematical notation and language; and present work orally or in writing with clarity and rigor, especially when writing a proof.
- Spatial—Construct geometric figures based on a given set of conditions; represent solid (three-dimensional) figures; prove theorems about the properties of plane (two-dimensional) figures; and perform transformations on figures.
- Numerical—Find and use relations among numbers; extend computational techniques to literal expressions; and estimate answers.
- Measurement—Measure areas and volumes.
- Statistics—Make representations of statistical problems and read them; and calculate the mean of a statistical distribution.

Exhibit 2 presents a summary of the mathematics concepts and skills to be covered in Grade 8 (Cycle 3 of basic education).

Exhibit 2: Mathematics Content in Basic Education, Grade 8

Content Area	Main Topics	Concepts and Skills Covered
Arithmetic and Algebra	Numbers	Natural numbers
		Integers
		Fractions
		Decimals
		Square Roots
	Operations	Powers of a positive number with a positive integer exponent
		Powers of a negative integer exponent of 10
	Proportionality	Inverse proportionalities

Content Area	Main Topics	Concepts and Skills Covered
Arithmetic and Algebra	Algebraic Expressions	Common identities
		Literal expressions with fractional forms
	Equations and Inequalities	Equations of the following types: $(ax + b)(cx + d) = 0$
		Equations and inequalities of the first degree with one unknown
Geometry	Location	Relative positions of two circles
		Geometric loci and constructions
		Coordinates of the midpoint of a segment
	Solid Geometry	Three-dimensional representations of cylinders, pyramids, cones, and spheres
		Relative positions of lines and planes
	Plane Figures	Pythagorean theorem
		Theorem of midpoints in a triangle and in a trapezoid
		Characteristic properties of a parallelogram
		Central angle in a circle and inscribed angle in a circle
		Area of a circular sector
	Transformations and Figures	Vector and translation
Statistics	Handling Data	Cumulative exact values and frequencies
		Representation of data, including circular diagrams and cumulative frequency polygons

Science Curriculum in Primary and Lower Secondary Grades

Science plays an important role in everyday life, and it manifests itself in all aspects of human activity. Consequently, it is important that students become lifelong learners of science, by learning it at school and extending science learning beyond school.

To achieve this goal, the general objectives of science teaching are the following: [3]

- Develop students' intellectual and practical scientific skills;
- Deepen students' awareness of man's ability to understand, invent, and create;
- Understand the nature of science and technology, their development across history, and their impact on human thought;
- Ensure that students have acquired the facts, concepts, and principles necessary to understand natural phenomena;

- Motivate students to apply basic scientific principles to all sciences;
- Explain the scientific concepts and principles behind commonly used machines and devices;
- Acquire knowledge about health, the environment, and safety practices, and behave accordingly;
- Realize that some natural resources can be depleted, and make the student aware of science's role in sustaining these resources;
- Encourage students to use scientific knowledge and skills in novel situations, especially in everyday life;
- Emphasize the role of scientists in the advancement of mankind;
- Encourage students to be open to the ideas of scientists from different cultures, and understand their contributions to the advancement of science;
- Encourage students to abide by scientific values, such as honesty and objectivity;
- Develop students' scientific curiosity and orientation toward scientific research;
- Encourage students to work independently and cooperatively when solving scientific problems; and
- Make students aware of career possibilities in different science-related areas.

Exhibit 3 presents a summary of the science concepts and skills to be covered in Grade 4 (Cycle 2 of basic education).

Exhibit 3: Science Content in Basic Education, Grade 4

Main Topics	Concepts and Skills Covered
Plants and Their Habitats	Fresh water plants Classification of plants
Animals and Their Habitats	Fresh water habitat Classification of animals
Man and His Health	The human body, its structure, and system of movement Food pyramid
Man and the Environment	(Included in the other themes)

Main Topics	Concepts and Skills Covered
Matter and Energy	Properties of matter
	Mixture
	Magnets
	Electricity
	Sound
Earth and the Universe	Soil
	Formation of soil
	Clay
	Rocks
	Fossils

Exhibit 4 presents a summary of the science concepts and skills to be covered in Grade 8 (Cycle 3 of basic education). At this level, life science and Earth science are taught together as one course.

Exhibit 4: Science Content in Basic Education, Grade 8

Content Area	Main Topics	Concepts and Skills Covered
Life and Earth Science	Nutrition	
	Reproduction and Genetics	Puberty and adolescence
		Reproductive organs
		Functioning of the reproductive system
		Fertilization, development, and birth
		Birth control
		Sexually transmitted diseases, including AIDS
	Immunology	Immunological specificity
		Deficiencies and disorders of the immune system
		Preventive and curative methods
	Earth and the Environment	Geology, including Earth science
		Manifestations of Earth's activities
		Structure and dynamics of the Earth
		Circulation of matter on Earth
		Geology and human responsibilities
Chemistry	Classification and Constituents of Matter	Pure substances, including elements, compounds, atoms, molecules, ions, and symbols and formulas
		Allotropes, including diamond and graphite
	Chemical Reactions and Energy	Electrical nature of matter, including electrification, electric discharge, conductors and insulators, and electricity and safety
		Chemical reactions, including chemical equations, types of chemical reactions, and rate of chemical reactions

Content Area	Main Topics	Concepts and Skills Covered
Chemistry	Chemical Reactions and Energy	Acids, bases, and salts, including acidic and basic solutions, acidity and the concept of pH and salts
		Applications
Physics	Mechanics	Motion and speed
		Force, including effects and classification
		Work, power, and forms of energy
	Heat	
	Waves	Characteristics of waves, including sound waves
		Electromagnetic waves and colors
	Optics	Rectilinear propagation of light
		Reflection of light and plane mirrors

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Mathematics is taught for five periods per week throughout basic education (Grades 1–9), for a total of 150 periods per year. Instructional time for science is more variable across grades and subjects. Exhibits 5 and 6 present the instructional time for science per week and per year at the primary and intermediate levels of basic education.

Exhibit 5: Distribution of Science Instruction in Basic Education, Grades 1–6 (Primary Level)

Grade	1	2	3	4	5	6
Number of Periods Per Week	2	2	3	4	4	5
Number of Periods Per Year	60	60	90	120	120	150

Exhibit 6: Distribution of Science Instruction in Basic Education, Grades 7–9 (Intermediate Level), by Subject

Grade	7	8	9
Life and Earth Sciences			
Number of Periods Per Week	3	2	2
Number of Periods Per Year	90	60	60
Chemistry			
Number of Periods Per Week	1.5	2	2
Number of Periods Per Year	45	60	60
Physics			
Number of Periods Per Week	1.5	2	2
Number of Periods Per Year	45	60	60

Instructional Materials, Equipment, and Laboratories

In public schools, only books produced by ECRD are used. In private schools, every institution is allowed to choose books produced either by ECRD or by private publishers. Science laboratories and equipment also are available in schools.

Use of Technology

The curriculum designates weekly periods for teaching students to use computers as a separate subject. However, neither teachers nor students are required to use computers in their courses, particularly in mathematics and science. The use of calculators (most kinds) is required in mathematics and is optional in other subjects.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

In Cycles 1 and 2 of basic education (Grades 1–6), generalist teachers teach mathematics and science, and the same teacher may teach mathematics, science, and language lessons. In Cycle 3 (Grades 7–9), there are two classes of teachers: generalist and specialized. All teachers in secondary education (Grades 10–12) must be specialists in the subject they teach. For example, a teacher who teaches a chemistry course must be a university graduate with a degree in chemistry.

Homework Policies

The curriculum does not contain any specific policy statements about homework. However, in practice, homework is given to students in Cycles 1 and 2 (Grades 1–6) once or twice a week, depending on the course and available teaching hours. Homework is corrected and evaluated by teachers. In Cycle 3 (Grades 7–9), homework is given in the form of exercises and problems to be prepared at home for subsequent correction.

Currently, ECRD is developing an evaluation system that will consider homework assignments in terms of types of homework, how much is assigned, and the evaluation methodologies used.

Teachers and Teacher Education

Teacher Education Specific to Mathematics and Science

As previously described, mathematics and science teachers in Cycles 1 and 2 (Grades 1–6) are general classroom teachers, not subject specialists. These teachers fall into the following two categories:

- Category 1—Teachers who are graduates of teacher education centers and either have completed three years in a center after obtaining their intermediate school certificate, or have completed a year and a half in a center after obtaining their secondary school certificate and are trained to teach all subjects (except languages).
- Category 2—Teachers who have obtained their secondary school diplomas and have not attended a center but have gone on to complete university courses.

Cycle 3 (Grades 7–9) teachers fall into the following three categories:

- Categories 1 and 2—(See above).
- Category 3—Teachers in the public sector who have a university degree in instructional pedagogy or are graduates of a university department of education.

Within the private sector, most teachers either belong to Category 2 or 3, and they are officially recognized as teachers on contract with private schools. The first category (i.e., graduates of teacher education centers) does not apply to private schools.

In order to fill vacancies resulting from the growth of public school attendance, particularly at the intermediate and secondary levels, the government recently instituted examinations to appoint secondary schools specialist teachers. These individuals were required to have university degrees in the subjects they were to teach. Once they passed the examination, these teachers were required to complete a one-year preparatory period within a university department of education in order to qualify for a teaching diploma in the relevant specialty.

Requirements for Ongoing Professional Development

Since the 1998–99 school year, all teachers have completed professional development sessions and have been required to attend refresher courses. Mathematics and science teachers attend special professional development sessions focused on active methodologies for teaching and learning in laboratories. Such sessions are conducted as qualification courses during summer vacations and as follow-up courses during the school year.

In order to monitor teacher performance and offer professional development on using technology, information, and communication technology, ECRD conducts training sessions at teacher training centers and secondary schools, as well as at other public schools. These sessions are offered outside of official working hours throughout the year.

Monitoring Student Progress in Mathematics and Science

Lebanon has three types of examinations: school, official, and central official examinations.

- School Examinations—Students attending public schools in Cycles 2 and 3 (Grades 4–9), as well as secondary level students (Grades 10–12), take two examinations during the school year, in addition to monthly tests.
- Official Examinations—Private schools apply the same examination system as public schools; however, students at private schools take three term tests each school year.
- Central Official Examinations—All students in public or private schools must take the central official examinations at the end of the basic education stage (Grade 9) to obtain an Intermediate Certificate, which is required for those who plan to pursue secondary education. At the end of the secondary stage (Grade 12), students are required to take all four portions of this examination—general science, life sciences, economics-sociology, and arts-humanities—in order to obtain a General Secondary School Certificate. Students may not enter university unless they obtain the General Secondary School Certificate. Students' school results are not taken into account in official examinations.

In public schools, students are promoted to the next grade, or repeat the same grade, based on the results of the examinations mentioned above. However, in Cycles 1 and 2, students are automatically promoted, and weaker students can receive remedial education through a booster program offered by the school. In private schools, the decision to promote or not to promote a student is made by considering results from the same tests and examinations administered to public school students.

Impact and Use of TIMSS

Since Lebanon began participating in TIMSS in 2003, no modifications or reviews have been made to the mathematics and science curriculum. Presently, however, ECRD is reviewing the curricula along with subject textbooks. In particular, ECRD is considering the results of TIMSS 2003, TIMSS 2007, and

TIMSS 2011, among other assessment results, for revisions to the eighth grade mathematics and the science curricula.[4] Because ECRD is the only official governmental institution that develops curricula in Lebanon, the president of ECRD is involved in the process of considering TIMSS results and their impact on mathematics and science reform for the eighth grade.

Suggested Readings

Educational Center for Research and Development, Ministry of Education and Higher Education. (n.d.). Retrieved from http://www.crdp.org/CRDP/default.htm

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1 Educational Center for Research and Development, Ministry of Education and Higher Education. (1997). *General objectives of the curricula and their details*. Beirut: Author.

2 Ibid.

3 Ibid.

4 Educational Center for Research and Development, Ministry of Education and Higher Education. (1994). *Plan for educational reform in Lebanon.* Beirut: Author.

Lithuania

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Introduction

Overview of the Education System

In Lithuania, the parliament defines the basic principles, structure, and objectives of education, while the Ministry of Education and Science devises and implements education policy through its various institutions. The ministry defines the curriculum in use throughout the country, and also determines teacher salaries, requirements for teacher qualifications, priorities for qualification development, and the assignment of educational staff. Local municipalities are responsible for administering and financing most general education and vocational schools (except some national-level schools).

Preprimary education in Lithuania is optional for children ages 1–6. Primary school consists of Grades 1–4 and is followed by basic school, which comprises Grades 5–10. Education is compulsory for all students up to the age of 16. Primary and basic schools follow a national curriculum, which schools and teachers are expected to adapt to their needs.

Upper secondary school consists of Grades 11 and 12. Gymnasia form a parallel system of education lasting four years and corresponding to Grades 9–12. Currently, schools are being reorganized so that there will be just three types of public schools: primary schools (Grades 1–4), pre-gymnasia (Grades 1–8 or 5–8), and gymnasia (Grades 9–12).

In Lithuania, many students proceed to universities after finishing secondary education. Because many universities require good results on mathematics examinations for admission, mathematics education is emphasized. The majority of students in secondary school choose to study higher-level mathematics, but the same cannot be said of the sciences. There are, however, a number of initiatives to promote mathematics and science in schools, including various competitions ranging from traditional Olympiads oriented towards very gifted students to those that are attractive to and can be achieved by most of the students and serve to promote interest in these subjects.

Languages of Instruction

In Lithuania, the official national language is Lithuanian, and the main minority languages include Russian and Polish. In most schools, the language of instruction is Lithuanian, but there are still a considerable number of schools with a language of instruction other than Lithuanian—mainly Russian or Polish. All schools with a language of instruction other than Lithuanian teach Lithuanian as a national language in addition to language of instruction as a mother tongue. In primary and basic schools, mathematics and science are taught in the language of instruction of the school.

Mathematics Curriculum in Primary and Lower Secondary Grades

According to the official national curriculum, mathematics education in primary school (Grades 1–4) aims to develop students' calculation, reasoning, and formalizing skills, as well as to develop students' visual, spatial, and statistical thinking.[1] Understanding and applying known mathematical concepts, models, methods, and relationships allows students to better know the world, solve everyday life problems, and adopt the culture of human thought and action developed through the centuries. Knowledge gained in various mathematical content areas should help students orient themselves in everyday life and prepare for further successful study of mathematics, natural sciences, and technologies. Through mathematics study, students should be able to communicate and collaborate using mathematical concepts as a means of conveying information, learn to use mathematical vocabulary and symbols, adopt elements of mathematical reasoning, and solve simple problems from everyday life that correspond to their experience and interests. Students should understand the importance of mathematics for their own and others' lives and its applicability in various spheres of practical human endeavors. Lastly, students should value the honesty, perseverance, and creativity needed for intellectual work, and desire additional mathematical knowledge and skills.

The primary school curriculum comprises several mathematics content areas: numbers; expressions, equations, and inequalities; geometry; measurement; and statistics. In the context of numbers, most attention focuses on students' developing strong skills in mental and written calculations in order to learn the names and components of arithmetic operations and the concepts of number, digit, and fraction (although students do not apply arithmetic operations to fractions in primary school). Exhibit 1 summarizes the knowledge content and specialized skills students learn in mathematics in Grades 3–4.

Exhibit 1: Mathematics Learning Objectives and Expectations, Grades 3–4

Content Area	Objectives and Expectations
Numbers	Read and write natural numbers up to 10,000, simple fractions with the following denominators of 2, 3, 4, 5, 6, 7, 8, 9, 10, 100, and decimal fractions with no more than two digits after the decimal point;
	Compare numbers of the same type, correctly using symbols such as <, >, or =;
	Identify how close a given number is to which multiple of ten, one hundred, or one thousand;
	Carry out practical counting tasks;
	Add and subtract natural numbers, multiply and divide by one- and two-digit numbers, and round three- or four-digit numbers (e.g., 100 or 1,000);
	Solve simple real-life and abstract problems, and estimate and check the results of calculations; and
	Explain the appearance of remainders from division in the context of concrete situations.
Expressions, Equations, and Inequalities	Calculate values of simple numerical expressions or quantities;
	Describe everyday practical and mathematical situations using simple numerical expressions;
	Use the commutative and distributive properties of addition and multiplication when rearranging simple numerical expressions; and
	Solve simple equations and inequalities in more than one variable by guessing the answer and checking the result.
Geometry	Recognize and draw points, segments, triangles, rectangles, squares, circles, cubes, parallelepipeds, pyramids, cones, and spheres;
	Show elements of triangles and rectangles (e.g., side, angle, and vertex) in models and sketches;
	Show radii of circles, edges, and vertexes and walls of cubes, parallelepipeds, and prisms in sketches;
	Identify symmetry in objects or geometric plane figures; and
	Apply knowledge about plane and solid figures to solve simple problems.
Measurement	Correctly read and write measurement results;
	Draw segments of a given length, rectangles of given dimensions, and circles of given radii;
	Estimate parameters of simple objects and things (e.g., length, width, and volume in liters), without using measuring instruments;
	Solve simple problems in which measurements are needed to carry out operations;
	Use calendars and schedules;
	Calculate average speed given distance and elapsed time; and
	Calculate the perimeter of a triangle and quadrilateral and the area of a rectangle.
Statistics	Collect data from the surrounding environment and display in a frequency table;
	Read information from bar graphs, pictograms, and frequency tables, and represent given (or collected) data in a bar graph; and
	Answer simple questions and draw simple conclusions based on given (or collected) data.

The basic education curriculum (Grades 5–10) emphasizes a strong knowledge of various mathematical content areas for orientation in everyday life and building a strong foundation for successful study of other subjects, such as the natural sciences and technology. It is expected that students should be able to communicate and collaborate using mathematical concepts as a means of conveying information, learn to use mathematical vocabulary and symbols, adopt elements of mathematical reasoning and activity, and conduct mathematical investigations of simple problems from every-day life. Further, students should be able to solve mathematics problems and understand and use relationships from mathematics. The curriculum conveys the need for students to understand the historical evolution of mathematics and explore ideas about modern areas of mathematics that contribute to advances in natural, social, and computer sciences. Students should recognize the importance of mathematics for society, its objectivity, and its practical applicability to various areas of human activity. Mathematics instruction aims to motivate students to seek mathematical knowledge and develop openness, perseverance, and positive attitudes toward change, will power, desire, and responsibility, as well as the need to learn and remain interested in other subjects which depend on mathematics.

At this level of education, the curriculum divides knowledge and special mathematical skills into several content areas: numbers; expressions, equations, inequalities and their systems; relationships and functions; geometry; measurement; statistics; and probability theory. The curriculum then further divides general skills and attitudes into knowledge and understanding, mathematical communication, mathematical reasoning, problem solving, and the ability to learn and become interested in mathematics. Exhibit 2 summarizes the knowledge content and specialized skills students learn in mathematics in Grades 7–8.

Exhibit 2: Mathematics Learning Objectives and Expectations, Grades 7–8

Content Area	Objectives and Expectations
Numbers	Read, write, and compare rational numbers, place them on a number line, round them to a specified digit, and use them in arithmetic calculations;
	Raise a rational number to a whole number power;
	Find square or cube roots of rational numbers;
	Continue to develop problem solving skills involving percentages; and
	Use a calculator to carry out various calculations and to check results.
Expressions, Equations, Inequalities, and Their Systems	Calculate values of simple numerical and algebraic expressions that may include two or three arithmetic operators, exponents, square roots, brackets, and one or two variables;
	Rearrange terms in polynomials and factor them in simple cases;
	Apply attributes of whole-number exponents, square, and cube roots in simple cases;
	Solve first degree equations and equations in the form of $A(x)\,B(x) = 0$, where $A(x), B(x)$ are first-degree binomials; and $ax^2 = b$ and $ax^3 = b$ $(a, b > 0)$; and
	Solve simple first-degree inequalities.

Content Area	Objectives and Expectations
Relationships and Functions	Represent two directly or inversely proportional quantities with tables, graphs or formulas, and apply the concept of proportionality; and Draw a figure symmetrical to a given one by applying point or line symmetry.
Geometry	Classify angles, triangles, and quadrangles according to given attributes; Apply properties of adjacent and vertical angles, and parallel lines in solving simple problems; Explore properties of triangles (isosceles and equilateral) and quadrilaterals (parallelogram and trapezoid), and apply the properties of congruence to triangles and symmetry to figures (point and line); Prove simple statements by using geometric properties (e.g., triangle congruence, the sum of triangle or quadrilateral angles, and the Pythagorean theorem); Draw right triangles or quadrilateral prisms, cylinders, cones, spheres, and regular pyramids, and name their elements; and Make models of right triangles or quadrilateral prisms, regular pyramids, and other regular solid figures.
Measurement	Read and write results of measurements in both standard and non-standard units; Estimate parameters of simple objects in the real world, with or without measuring instruments; Use formulas to find perimeter and area of triangles, parallelograms, trapezoids, and circles; Understand and use properties of length, width, and area; Apply measurement scales to solve problems that require finding length (perimeter) or area of figures; Calculate the sum of the angles in triangles or quadrilaterals; Calculate the volume and surface area of right prisms and cylinders; Establish relationships among various measurement units; Add and subtract measurements in the same units and multiply and divide measurements in any units; and Find speed, distance, and time with relevant formulas.
Statistics	Find and analyze diverse statistical information from different sources; Interpret and evaluate sample characteristics; and Visualize data and find numerical characteristics using spreadsheets (e.g., with Microsoft Excel).
Probability Theory	Make subsets of several elements, with elements taken from different sets or from the same set; Distinguish whether order in a subset is important; Use the rule of multiplication while calculating a number of subsets only when the order of elements in the subset is important; Become acquainted with the notions of probability experiments and the outcomes of such experiments; and Conduct experiments, learn how to calculate relative frequency of outcomes, and draw simple conclusions about the likelihood of each outcome.

Science Curriculum in Primary and Lower Secondary Grades

In primary school (Grades 1–4), the curriculum divides integrated social and natural science into several content areas: people living together, people's development, people's environment, people's health and safety, people and nature, and people and natural phenomena. The latter four areas mainly deal with natural science, and Exhibit 3 summarizes the knowledge content and specialized skills students learn in these content areas during primary school.

Exhibit 3: Science Learning Objectives and Expectations, Grades 1–4

Content Area	Objectives and Expectations
People's Environment	Learn about general weather changes and geographical attributes of Earth.
People's Health and Safety	Learn about the human body and functions, in a simple and understandable way; Learn proper breathing, posture, vision, hearing, and hygiene; Become acquainted with first aid for oneself and others; Develop healthy diet and personal hygiene habits; Become acquainted with causes and prevention of contagious diseases; Learn where to go and whom to contact in case of accidents, and how to protect oneself from them; and Learn how to resist alcohol abuse, how to calm down and relax in a stressful situation, and how to actively rest.
People and Nature	Learn to observe and remember facts, and link them to sets of causal relationships; Pay attention to natural surroundings and the interrelationships of various life forms; Explore the interrelationships of plants and animals (based on examples of forest or pond ecosystems); Recognize that the environment and natural phenomena (sun, air, and water) help sustain life; Recognize the importance of solar energy for life on Earth; and Emphasize consequences of human activities on nature.
People and Natural Phenomena	Learn to investigate natural phenomena; Using illustrations from everyday life, explore movement and its laws, the phenomenon of electricity, sources of energy and ways of saving energy, properties and changes of materials, the phenomenon of burning, and water circulation in nature; Learn to formulate hypotheses, predict results, and draw conclusions; Learn to apply scientific methods to analyze simple problems; Develop the ability to distinguish what is true from what is probable; and Learn to plan and to conduct experiments, using simple instruments from everyday life as well as basic laboratory equipment.

Science education in basic school (Grades 5–10) provides an opportunity for all students to acquire foundational knowledge of natural science. This education enables students to master essential concepts and ideas from natural science, acquire skills that will help them know the world, and develop certain values and attitudes. Students mature as citizens able to live healthy lives and solve sustainable development problems. In Grades 5–6 of basic school, students learn science as an integrated subject and learn only Geography as a separate subject in Grade 6. From Grade 7, however, biology, chemistry, and physics are taught as separate subjects. Overall, the science curriculum focuses on knowledge and understanding, problem solving, practical skills, scientific communication, and skills for learning science. Exhibit 4 summarizes the four dimensions and nine content areas of natural science in Grades 7–8 of basic school.

Exhibit 4: Science Learning Objectives and Expectations, Grades 7–8

Dimension	Content Area	Objectives and Expectations
Science Investigations	Science Investigations	Continue to learn the sequence of science investigation, including formulating a hypothesis based on life experience, planning and carrying out simple experiments and observations, presenting results, formulating conclusions, and identifying the main factors that influence studied phenomena; Learn to predict and check relationships between two or more variables based on scientific laws; Learn to search, summarize, and present information from various sources to others; Explore the influence of the natural sciences and technology on human life; Learn to apply science knowledge to explain phenomena; Explore the problem of sustained development in the context of social and economic factors; Investigate which personal qualities support the study of natural sciences; and Learn strategies for studying science.
Living Nature (Biology)	Structure and Function of Organisms	Explore the following: structural and functional links of cells, tissues, and organs; photosynthesis and breathing; metabolism of substances and energy; food and a balanced diet; nervous system and substances which affect its function; and reproduction, sexual intercourse, and healthy living.
	Continuity and Diversity of Life	Explore the transmission of inheritable traits, evolution and adaptation of organisms, and classification of organisms.
	Organisms and the Environment: Humans and the Biosphere	Explore the movement of substances and energy in ecosystems and populations, and the influence of environmental pollution on organisms.
Matter and Change (Chemistry)	Knowledge of the Composition and Characteristics of Matter	Explore the following: periodic table of elements, periods and groups, and composition of an atom; chemical elements and formulas; homogenous and heterogeneous mixtures; and physical attributes of substances (e.g., mass and density).
	Changes in Matter	Explore physical and chemical changes, signs of chemical reactions, and necessary conditions for the processes, and Avogadro's number and the mole.
	Knowledge about and Use of Common Substances	Explore the following: air, oxygen, oxides, and ozone; chemical substances in everyday life; and the influence of human activities on the environment.

Dimension	Content Area	Objectives and Expectations
Physical Phenomenon (Physics)	Knowledge of Motion and Forces	Explore the following: rectilinear and curvilinear motion, distance, speed, average speed, and acceleration; interaction between objects; inertia; mass; the relationship among force, mass, and acceleration; action and reaction forces; types of forces; equilibrium of bodies, center of mass, and moment of inertia; and hydrostatics and atmospheric pressure.
	Knowledge of Energy and Physical Processes	Explore the following: mechanical energy, work, power, potential and kinetic energy, and the law of conservation of energy; simple machines; molecular composition of matter (solids, liquids, and gases); thermal expansion of bodies; electrical currents and circuits; free and forced vibration; mechanical waves and sound; and light and laws of reflection and refraction.
	Knowledge of Earth and the Universe	Explore the phases of the moon, and the movement of the planets.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Materials, Equipment, and Laboratories

Textbooks, exercise books, and teacher's editions of textbooks are the main instructional materials for teaching mathematics and science, both for integrated science courses in earlier grades and for specialized subjects in later grades. In most cases, teachers can choose among several types of textbooks for specific science instructional use, and teachers frequently use one textbook as the primary teaching tool, accompanied by additional supplementary materials. All textbooks and educational computer programs must receive official approval from expert panels at the Ministry of Education and Science. Other materials do not need approval.

Many schools still have remnants of old laboratories and laboratory equipment, but some schools cite a lack of such teaching tools. In recent years, however, a number of projects have begun to supply schools with laboratories and laboratory equipment for teaching science.

Use of Technology

Since 2008, students have been taught information technology beginning in Grade 5, although primary school teachers also use computers at their discretion.

Some computer programs that can be used in teaching mathematics and science are starting to appear; however, because teachers have not extensively used or learned to use them, such resources often are not included in instruction. There are also a number of technology projects in development, including distance learning and electronic teaching tools, along with programs to train teachers in their use.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

In primary school (Grades 1–4), classroom teachers teach all subjects, including mathematics and science. Beginning in Grade 5, there are specialist teachers for both mathematics and science. In Grades 5–6, a science subject teacher teaches the integrated science course. Beginning in Grade 7, when specialized science subject lessons start, individual subject teachers provide instruction.

Homework Policies

Educational plans recommend that teachers do not assign homework in primary school. These plans also define certain limitations for homework assignments at other grades. For example, teachers are asked not to assign homework before weekends and holidays. Teachers who teach the same groups of students are expected to coordinate homework assignments among themselves.

Teachers and Teacher Education

Primary school (Grades 1–4) teachers receive their education either at pedagogical universities or at one of two teacher education colleges. Courses of study include education in the subjects taught at the primary level as well as general courses in pedagogy and psychology.

Basic school (Grades 5–10) teachers receive their education either at pedagogical universities or at general universities and complete professional teachers' studies in addition to their bachelor's program studies. Science teachers in pedagogical universities usually receive their training in two subject areas—for example, biology and chemistry, or physics and technology. Teachers are expected to teach the subjects that they were educated in.

The majority of teachers in primary and basic schools (almost 94%) have university level education, almost 5 percent have post-secondary tertiary education, and less than 2 percent have secondary level education.[2] About 97 percent of primary school teachers and 93 percent of basic school teachers have pedagogical qualifications.[3]

Since 2010, a new regulation for teacher education gave added emphasis and support for teacher preparation in various higher education institutions. However, during the administration of TIMSS 2011, teachers educated in the new system had not yet begun formal classroom practice.

Monitoring Student Progress in Mathematics and Science

There are no national examinations at the primary level. Students take examinations at the end of basic school (Grade 10) and at the end of the secondary school (Grade 12). The examinations at the end of basic school comprise mother tongue and mathematics, and students in language minority schools also take an examination in Lithuanian language.

At the end of secondary school (Grade 12), the range of final examinations (the *Matura* or *Brandos* examinations) is much wider. Lithuanian language (either as a mother tongue or as a national language) is the only compulsory examination. Students are free to choose other examinations from a large list, including mathematics, biology, physics, chemistry, geography, history, foreign languages, art, music, informatics, and mother tongue (for language minorities). However, to receive the secondary school leaving (*Matura*) certificate, students must pass at least two examinations.

Lithuania also administers national sample surveys in mother tongue, mathematics, science, and social science at Grades 4, 6, 8, and 10, which provide national level information about the main areas of education. Sometimes, and in some districts, all students are tested to monitor school conditions and make educational management decisions. After these surveys, example questions with scoring instructions and national level statistics are made available and can be used by teachers to gauge the relative achievement of their students.

Recently, a major project to develop standardized tests in Lithuania has been launched, because although a number of commercial tests are be available, their quality is doubtful and they are certainly not standardized. The project also aims to address another issue—the fact that diagnostic testing often is not used in Lithuania; although schools might use some tests to identify children with mental disabilities or very gifted students, there are no tests for the general student body.

Primary school students (Grades 1–4) do not receive grades, but written detailed explanations of their achievements based on teacher observations. Beginning in Grade 5, after a transitory period lasting about a half a year, teachers begin giving grades on a scale from one to ten to measure student attainment, with four being the minimal "passing" grades and ten considered an "excellent" grade. The curriculum provides general directions for assigning grades to particular levels of attainment, but teachers generally use their professional discretion to determine them.

Impact and Use of TIMSS

Lithuania has participated in TIMSS since 1995, when the educational system was just starting to see the effects of post-soviet reforms. TIMSS was the first major educational survey carried out in Lithuania, providing a valuable opportunity to collect trend data throughout this very important transition period. The TIMSS assessment also provided educational specialists involved in forming new mathematics and science subject content an opportunity to access the conceptual frameworks of major educational areas in the international community. This certainly influenced reforms in mathematics and science teaching and learning, which were carried out in the "TIMSS spirit." Not surprisingly, the results of Lithuania's students on TIMSS have been increasing gradually with each TIMSS survey cycle.

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Republic of Macedonia

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Introduction

Overview of the Education System

Primary and secondary education is compulsory in the Republic of Macedonia, and is equally accessible and free to everyone. The new 2001 constitution gives citizens the right to establish private educational institutions at all levels except primary.[1] The Ministry of Education and Science is responsible for national education policy, including implementing and financing education, overseeing state institutions, and establishing and monitoring education laws and regulations.

Several entities within the Ministry of Education and Science carry out various functions and duties. The Bureau for Development of Education is in charge of developing curriculum for primary school and for academic subjects in secondary school, providing professional support to school improvement efforts, providing professional development to school staff, and accrediting teacher education providers. The Vocational and Educational Training Center is responsible for curriculum development for vocational schools. The National Examination Center is responsible for external assessment of student achievement in primary and secondary education. The State Educational Inspectorate supervises legal and regulatory matters at all levels of education, and monitors and evaluates school quality. The Pedagogical Service inspects and approves curricula, textbooks, and projects implemented in primary and secondary education.

As a country in transition, the Republic of Macedonia has been working toward decentralizing its education system and improving quality, equality of opportunities, and efficiency. Professional and technical assistance, as well as capacity building, have been necessary in a number of areas to accomplish these goals. For these reasons, the Ministry of Education and Science developed the Decentralization Project and made changes in the legal framework to redefine the education system's roles and functions. In June 2005, the ministry began decentralization by transferring responsibility for school maintenance to municipalities. In July 2007, the ministry continued the process by transferring teacher employment and salary decisions to municipalities.

The education system in Macedonia is comprised of preschool, primary, secondary, and higher education. Preschool education is intended for children from seven months to five years old. Primary education is compulsory for students ages 6–15, and prior to 2007 had been divided into two four-year cycles: general classroom education, from Grades 1–4; and subject specific education, from Grades 5–8. Beginning in the 2007–08 school year, the system changed to nine-year primary education with three three-year cycles, and students now begin school by age 5½.[2]

Secondary education includes gymnasia, two-, three- and four-year vocational schools, and four-year art school (art, music, or ballet). Students who take gymnasium classes and students from four-year vocational schools usually continue on to university education.

Languages of Instruction

The official language in the Republic of Macedonia is Macedonian; however, all national groups in Macedonia are entitled to primary and secondary education in their native language. In primary school, instruction is provided in Macedonian, Albanian, Turkish, and Serbian. In secondary school, instruction is provided in Macedonian, Albanian, and Turkish. The Albanian population also has the right to Albanian language education at the university level, in some schools.

Mathematics Curriculum in Primary and Lower Secondary Grades

Mathematics is introduced beginning in the first grade and is taught each year through the eighth grade. Exhibits 1–3 present the goals of the mathematics curricula in terms of what student should be able to do in each of the three primary education cycles: Grades 1–3, Grades 4–6, and Grades 7–9.

Exhibit 1: Mathematics Goals, Grades 1–3[3]

Goals
Form a union of two or three sets;
Read, write, and compare numbers;
Determine even and odd numbers;
Identify the predecessor and successor of a given number to 100;
Use ordinal numbers to 100 in specific situations;
Apply knowledge of addition and subtraction of numbers up to 100 in solving numerical expressions and word problems with one or two operations;
Solve equations with one unknown and check the accuracy of the solution of the equation;
Apply knowledge of addition and subtraction to solve problems in situations from everyday life;
Recognize geometric concepts (e.g., point, line, segment, triangle, rectangle, square, circle, cube, sphere, cylinder, pyramid, and cone);
Label and names sides and vertices of triangles, rectangles, and squares;
Identify and determine the adjacent and opposite sides of rectangles and squares;
Know tables of multiplication and division of numbers up to 100;
Apply knowledge of multiplication and division to solve numerical expressions and word problems with one operation, including problems in situations from everyday life;
Recognize, graphically represent (by coloring or hatching), and write the fractions ½, ¼, and 1/8;
Recognize and apply basic units of length (cm, dm, m), mass (kg), time (min, h) and volume (l);
Use measuring instruments including rulers, meter sticks, scales with weights, and clocks;
Use knowledge about measurement units in problem-solving situations, estimating, and measuring;
Collect and select simple data and input and arrange it in tables; and
Read and interpret data from pictorial displays, charts, and graphs.

Exhibit 2: Mathematics Goals, Grades 4–6[4]

Goals
Perform basic arithmetic operations on the set of natural numbers and a subset of the positive rational numbers (fractions with equal denominators and decimal numbers);
Solve problems from practical situations in everyday life;
Know basic geometric concepts and identify and describe rays, segments, planes, angles, polygons, triangles, rectangles and squares, cubes, pyramids, cylinders, and cones and spheres;
Know how to use instruments for measuring length, mass, time, and fluid volume; understand and apply unit measures; and convert measurements from larger units to smaller units and vice versa;
Apply acquired mathematical knowledge to calculate the value of numerical expressions and solve equations and problems from everyday life; and
Collect, classify, compare, read, present, and interpret data.

Exhibit 3: Mathematics Goals, Grades 7–9[5]

Goals
Perform arithmetic operations with fractions with different denominators and decimal numbers;
Convert fractions to decimal numbers and percentages and vice versa;
Use properties of rational numbers to solve problems;
Calculate values of numerical expressions, solve linear equations and check solutions, and solve word problems using rational numbers;
Factor integers or whole numbers;
Calculate an unknown member of a proportion and graphically represent proportional and non-proportional sizes;
Solve linear inequalities and represent solutions in various ways;
Graphically represent linear functions and examine properties of functions;
Solve systems of linear equations with two unknowns using various methods (e.g., graphically, using substitution, and using linear combination);
Solve word problems from everyday life, science, and technology involving linear equations with one unknown or a system of linear equations with two unknowns;
Perform arithmetic operations with degrees and solve simple problems that use relationships between angles;
Construct figures with axial symmetry and central symmetry, and determine the axis of symmetry and center of symmetry of figures;
Calculate the perimeters of triangles, squares, convex polygons and circles, and the length of an arc; calculate the areas of triangles, squares, regular polygons, circles and parts of a circle; and calculate surface area and volume of prisms, pyramids, cylinders, cones, spheres and parts of a sphere;
Use the properties of similar triangles to solve simple problems;
Add and subtract vectors;
Apply the Pythagorean theorem to practical tasks;
Use Thales' theorem of proportional segments to solve problems;
Represent three-dimensional objects in two dimensions;
Apply formulas for the surface area and volume of geometric objects to solve problems;
Collect, collate, and represent data in different ways;
Calculate mode, median, range, and arithmetic mean of data and perform basic data analysis; and
Determine the probability of random events in simple examples.

Science Curriculum in Primary and Lower Secondary Grades

In Grades 1–4, science instruction is presented as a program of nature study. The goals of the curriculum are for students to be able to do the following: know some geographical terms (e.g., hill, mountain, river, and lake); name the parts of plants; name types of life cycles; know the similarities and differences between plants, animals, and man; know several ways of preserving and protecting the environment; know the conditions required for life; and know Earth's orientation in space. [6]

In Grade 5, instruction in the natural sciences enables students to expand their knowledge of the concepts and laws of nature.[7] Also, students should understand the concepts of systems, movements in the solar system, planets, physical laws on Earth, the structure of the Earth, forms of energy, air and water movement, and electricity. Natural science also helps students discover and implement the ways and means by which people interact with the Earth. Students learn about natural processes (e.g., rotation, revolution, and climate belts) and their consequences on the living world, and understand and appreciate the human activities that disturb the environment in an urban setting.

In Grade 6, students expand and deepen their understanding of basic principles and concepts of the natural world around them through the subject of natural sciences and technology.[8] They also study systems, the organization of the solar system, and the movement of its components, including Earth and other planets. Students learn about the structure of land formations and natural phenomena, such as earthquakes, volcanoes, storms, hurricanes, tsunamis, erosion, tides, and rains and the consequences of global warming and cooling. They also study how rocks and soil types are created, explain the basic concepts of diversity in the living world, and recognize the characteristics of living organisms, including that they are constructed of cells and that they carry out certain vital functions. Also, students must be able to describe the life functions of living organisms, including humans, and understand how living organisms are connected through the food chain. Students should understand the levels of organization in ecological systems (i.e., organism, population, community, ecosystem, biome, and biosphere) and the various conditions that have effects on communities and populations.

The science subjects of geography and biology are taught in Grades 7–9, while chemistry and physics are taught in Grades 8–9. Exhibits 4–7 present the goals of these curricula that students should understand and achieve through these subjects.

Exhibit 4: Geography Goals, Grades 7–9[9]

Goals
Understand basic geographical terms and knowledge about objects, phenomena, and processes through concrete examples;
Understand and apply the concept of proportionality and use techniques and instruments for orientation with maps;
Analyze and link social and natural factors in the development of the Earth and present numerical data in the form of diagrams, tables, and drawings;
Develop interest in the geographic characteristics of the Republic of Macedonia and other countries in a sociopolitical context; and
Become equipped with knowledge about the distribution of plants and animals on Earth, basic principles of environmental protection, and the peoples and countries of the world (i.e., characteristics, similarities, and differences).

Exhibit 5: Biology Goals, Grades 7–9[10]

Goals
The role and importance of biology as a science for the development and progress of humankind;
The basic biological properties of living organisms, including the structure and function of cells and the conditions for the survival and sustainable development of living organisms on Earth;
The dynamics of transformations of matter in nature and the flow of energy associated with these transformations;
The forms and functions of living organisms, including humans;
The historical basis for the interconnection of all living organisms;
The conditions and consequences of the formation of communities and species;
Factors affecting species endangerment and extinction;
The dynamic nature of organizations, processes, and phenomena associated with life cycles;
The variability and diversity of the living world in a changing environment;
Reproduction (sexual and asexual) and inheritance; and
The structure and function of the human body, hygiene habits, and responsibility for health of humankind.

Exhibit 6: Chemistry Goals, Grades 8–9[11]

Goals
The classification, composition, and particulate structure of matter (e.g., elements, compounds, mixtures, molecules, atoms, protons, neutrons, and electrons);
Solutions (e.g., solvent, solute, concentration and dilution, and the effect of temperature on solubility);
Properties and uses of common acids and bases; and
Chemical changes (e.g., transformation of reactants, evidence of chemical change, conservation of matter, common oxidation reactions such as combustion, rusting, and tarnishing).

Exhibit 7: Physics Goals, Grades 8–9[12]

Goals
Physical states and changes in matter (e.g., explanations of properties in terms of the movement and distance between particles, phase change, thermal expansion, and changes in volume and pressure);
Forms of energy transformations, heat, and temperature;
Basic properties and behaviors of light (e.g., reflection, refraction, color, and simple ray diagrams) and sound (e.g., transmission through media, loudness, pitch, amplitude, frequency, and relative speeds of light and sound);
Electric circuits (e.g., flow of current, components arranged in parallel and series, and the relationship between current and voltage), and properties and uses of permanent magnets and electromagnets; and
Forces and motion (e.g., types of forces, basic description of motion, and effects of density and pressure).

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Every school year the Ministry of Education and Science issues a school calendar, specifying the distribution of school days, school-free days, and school holidays. The syllabus specifies the number of yearly and weekly lessons for individual subjects. In general, lessons are 45 minutes long. Mathematics instruction in primary education for all grades is four hours per week, or 144 hours per year, which is approximately 20 percent of the total instructional time. In Grades 1–3, the program of nature study is taught for two hours per week in Grade 1, and three hours per week in Grades 2–3. In Grades 5–9, the amount of science instruction varies by subject: natural science is taught for two hours per week in Grade 5; natural science and technology is taught for three hours per week in Grade 6; geography and biology are each taught for two hours per week in Grades 7–9; and chemistry and physics are each taught for two hours per week in Grades 8–9.[13]

Instructional Materials, Equipment, and Laboratories

For each grade in primary education there are two textbooks from which teachers can choose. Worksheets are available for teachers and students and an exercise book also is provided for mathematics in each primary grade. The Ministry of Education and Science provides textbooks free of charge for each student. During the last five years, the Ministry of Education and Science also has made a great effort to supply schools with software, instructional materials, equipment, laboratories, and a computer for every student.

Use of Technology

The use of modern technology is a recent development in primary schools, and the government intends to enhance technology use in teaching and learning through such projects as A Computer for Every Child. Almost every student in school has access to computers. Educational software for mathematics and science has been adapted to suit the national mathematics and science curriculum and has been translated to Macedonian and Albanian for use in primary education. As of 2010, the Bureau for Development of Education recommends using computers in 30 percent of instruction.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Students in Grades 1–5 have one general classroom teacher for all subjects except foreign language. Students in Grades 6–9 have specific teachers for each subject who are specialists in the subject area, including mathematics and the sciences (geography, biology, chemistry, and physics).

Homework Policies

Teachers have their own policies regarding assigning, checking, and correcting homework. Generally, science teachers assign less homework than mathematics teachers. During most lessons, mathematics teachers assign homework, which is checked, but not graded, during the following lesson.

Teachers and Teacher Education

According to the Law for Elementary Education, individuals may become classroom teachers after completing a tertiary degree program at a Pedagogical Department or Institute of Pedagogy at a university Department of Philosophy.[14] This is a four-year program which prepares teachers to teach Grades 1–5. Subject teachers for Grades 6–9 are trained in their respective academic discipline for that subject. The third and fourth year of these programs includes a compulsory teaching practicum.

Requirements for Ongoing Professional Development

By law, the Bureau for Development of Education is responsible for providing professional support to primary schools by assisting school improvement efforts, providing professional development of school staff, and accrediting teacher education providers. Almost every year the bureau organizes some seminars for teachers at this level.

From 2006–11, the United States Agency for International Development (USAID) funded a large project for primary school called the Primary Educational Project (PEP).[15] The main objective of the Improving Mathematics and Science Education component was to build the critical thinking skills students need to succeed in a knowledge-based global economy. To achieve this objective, PEP worked on the following:

- Providing professional development for mathematics and science teachers in using contemporary student-centered teaching approaches;
- Developing school-based and national networks to support teacher professional development;
- Developing challenges for students; and
- Developing print and digital resources to improve teaching and learning.

UNICEF's project for Improving Mathematics and Language Literacy for Grades 1–3 in lower primary school was completed in 2010.[16]

Monitoring Student Progress in Mathematics and Science

National assessments of mathematics have been administered to students at the end of Grade 4 since 2001, and at the end of primary education since 2006.[17, 18] A national assessment in natural science for students in Grade 4 also began in in 2006.[19] The aim of these assessments is to provide the educational administration and professional institutions with valid data about student achievement that can be used to inform educational policy and give the schools and teachers information to improve teaching and learning.

The *Matura* examination is one of the national-level examinations administered at the completion of secondary education. Every student takes *Matura* examinations in four subjects, in addition to completing project work.

In 2009, the National Examination Center was established within the Bureau for Development of Education (previously the Assessment Unit). The general purpose of this center is to organize and conduct different kinds of assessment in primary and secondary education.

At the school level, teachers evaluate progress in student achievement with several forms of assessment, such as oral questioning and testing, with teachers preparing their own tests. In 2011, in order to help teachers improve the process of preparing examinations, the National Examination Center collaborated with the USAID-PEP project in creating a web-based item bank. Currently, the database contains questions pertaining to all subjects taught in the primary and secondary schools.[20]

Student achievement results in Grades 1–3 are expressed in the form of descriptive grades, which include the standards of knowledge the student has achieved. Second cycle students (Grades 4–6) are evaluated using numerical grades accompanied by verbal explanations. In the third cycle, numerical grades from 1 to 5 (1=basic, 5=excellent) are the most commonly used summative marks for evaluating student achievement. Following completion of each grade, primary and secondary schools provide each student with a report card containing his or her final grades in each subject.

Impact and Use of TIMSS

The impact of TIMSS (and PIRLS) on the Macedonian government and the Ministry of Education includes the following:

- An awareness of Macedonian students' low results in mathematics, science, and language literacy;
- An awareness of the need for external measurement (evaluation) of student achievement;
- An awareness of the need for developing assessment standards;
- The establishment of the Assessment Unit (now the National Examination Center) within the Bureau for Development of Education in 1999; and
- The establishment of the national assessment in primary education (in mathematics, language literacy, and science at end of Grade 4; in mathematics and language at the end of Grade 8; and in civic education at Grades 4 and 6).

TIMSS and PIRLS also have had the following implicit impact on the new Macedonian curriculum:

- Beginning compulsory education at age six, and introducing language curriculum for Grade 1;
- Introducing the compulsory integrated science subject in Grade 5;
- Introducing the compulsory integrated natural science and technology subject in Grade 6;
- Introducing the elective environmental subject in Grades 7, 8, and 9;

- Increased emphasis on physical geography vs. economic geography in Grades 6 and 7;
- Increased emphasis in developing skills in all mathematics and science subjects;
- Introducing a project-based learning approach; and
- Developing assessment standards and grading criteria.

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Introduction

Overview of the Education System

Providing quality education is one of the main responsibilities of the government of Malaysia, and the Ministry of Education is committed to providing a comprehensive education to all students. The government funds 95 percent of primary and secondary education and about 60 percent of tertiary (higher) education. The Malaysian education system encompasses preschool through university; preschool, primary, and secondary education fall under the jurisdiction of the Ministry of Education, while tertiary education falls under the supervision of the Ministry of Higher Education.

Malaysia's goal is to be a regional center of excellence in education. As a result, the education system always has been receptive to innovation and change. The main purpose of education in Malaysia is to enhance literacy and knowledge and to promote intellectual as well as emotional growth.[1] This national aspiration is reflected in the mission statement of the Ministry of Education: "to develop a world class quality education system which will realize the full potential of the individual and fulfill the aspirations of the Malaysian nation."[2]

Malaysia provides eleven years of free primary and secondary education (Grades 1–11). Students are admitted to the first year of primary education beginning at age six, and primary schooling is compulsory for all children between the ages of six and eleven. Primary education is divided into two levels: Level 1 (Grades 1–3), and Level 2 (Grades 4–6). Upon completion of secondary education (Grades 7–9), students can opt to pursue one to two years of post-secondary education, which is the university entrance preparatory course.

Languages of Instruction

Bahasa Malaysia is the national language and the official language of instruction in all schools, though English is widely spoken by Malaysians. While the national language is promoted by the government to foster national unity, people are free to use their mother tongue and other languages in their daily activities.

Primary schools provide instruction in the languages of the three main ethnic groups that comprise the Malaysian community: Bahasa Malaysia, Chinese, and Tamil. At the secondary level, Bahasa Malaysia is the language of instruction, although since 2003, English has been the language of instruction for mathematics- and science-related subjects. By studying both subjects in English, assisted by information and communication technology, students have greater opportunity to enhance their knowledge and skills as well as access to printed and electronic information written in English.

The Malaysian Curriculum in Primary and Lower Secondary Schools

Since 1983, the ministry has implemented the Integrated Curriculum for Primary School, which specifies standards for each level of primary education.[3] Level 1 (Grades 1–3) emphasizes acquiring strong reading, writing, and arithmetic skills. At Level 2 (Grades 4–6), the mastery of these basic skills is reinforced to build a strong foundation for basic sciences.

The mathematics and science curricula at the primary level were revised in 2011 and will be implemented gradually, one grade per year (i.e., Grade 1 in 2011, Grade 2 in 2012, etc.).[4] The revised mathematics curriculum is organized into four learning areas: Numbers and Operations, Measurement and Geometry, Relationships and Mathematical Connections and Algebra, and Statistics and Probability. The revised primary level science curriculum is organized into six themes: Introduction to Science, Life Science, Physical Science, Material Science, Earth and Space Science, and Technology and Sustainable Living.

Since 1989, the Integrated Curriculum for Secondary School has been in effect.[5] This curriculum covers a wide range of subjects including the arts and sciences, as well as vocational and technical subjects. Specifically, the goal of the mathematics curriculum is to develop individuals who are able to think mathematically and who can apply mathematical knowledge effectively and responsibly in solving problems and making decisions.[6] The goal of the science curriculum is to accomplish the following: provide students with knowledge and skills to solve problems and make decisions in everyday life, guided by moral values; pursue further education in science and technology; and develop a concerned, dynamic, and progressive society imbued with a science and technology culture that values nature and works towards the preservation and conservation of the environment.[7]

Mathematics Curriculum in Primary and Lower Secondary Grades

The curriculum that was in effect for students assessed in TIMSS 2011 was the Integrated Curriculum for Primary School from 2003. At the primary level, this curriculum is organized into four learning areas: Numbers, Measurement, Shape and Space, and Statistics.[8] For each area, topics are listed from the most basic to the most abstract. This enables teachers to have a good understanding of the development and scope of each topic, thus giving them the framework to plan lessons according to student ability. Problem-solving and communication skills are incorporated into each topic.

Upon completing Grade 4, students should be able to do the following:

- Numbers—Perform mathematical operations and solve problems involving whole numbers up to 100,000; compare, express equivalent fractions, and add and subtract proper fractions with denominators up to 10; write decimals, convert fractions to decimals, perform mathematical operations, and solve problems involving a maximum of two decimal places; and write values, perform mathematical operations, and solve problems involving money up to, RM10,000 (RM, Malaysia Ringgit, is the country's currency).
- Measurement—Learn about time, including understanding the twelve-hour system, performing mathematical operations, and solving problems involving units of time and the calendar; measure length, mass, and volume of liquid in metric units; do conversions involving the respective units; perform mathematical operations; and solve problems involving length, mass, and the volume of liquid.
- Shape and Space—Identify two- and three-dimensional shapes; calculate perimeters, areas, and volumes; and solve problems involving perimeters, areas, and the volumes of squares, rectangles, cubes, and cuboids.
- Statistics—Extract and interpret information from pictographs and bar graphs.

For Grades 5–8, the curriculum is organized into three interrelated learning areas: Numbers, Shape and Space, and Relationships.[9] The scope of each topic in terms of what students should be able to do upon completing the eighth grade is as follows:

- Numbers—Perform computations and solve problems involving integers, fractions, decimals and percentages; perform operations involving negative numbers; understand number patterns and sequences, such as multiples and factors; and use calculators to explore concepts regarding squares, square roots, cubes, and cube roots of numbers.

- Shape and Space—Understand basic measurements involving length, mass, and time and estimate and solve problems related to basic measurements; (Pythagorean Theorem) solve problems involving polygons, geometric solids, lines and angles and the Pythagorean Theorem; (Geometrical Construction) perform constructions using straight edges and compasses; (Coordinates) use scales, plot Cartesian coordinates of points, and solve problems involving coordinates and the distance between two points and midpoints on a Cartesian plane; (Loci in Two Dimensions) determine the locus of points that satisfy given conditions and the intersection of two loci; (Plane Geometry) identify the parts of a circle; draw a circle given the measurements of the different parameters of the circle; and solve problems involving circumference, areas of sectors, and areas of circles; (Transformations) determine the image of an object and solve problems involving translation, reflection, and rotation; use the concept of isometry when constructing patterns; solve problems involving congruence, and determine properties of quadrilaterals using reflections and rotations; (Solid Geometry) identify geometric properties of prisms, pyramids, cylinders, cones, and spheres; construct models of solids, given their nets; and solve problems involving surface areas of prisms, pyramids, cylinders, cones, and spheres.
- Relationships—Perform computations and solve problems involving algebraic terms and expressions; (Linear Equations) write linear equations and solve problems involving linear equations with one unknown; (Ratio, Rates, and Proportion) solve problems involving ratios and proportions of two and three quantities; (Statistics) collect and record data systematically; determine the frequency of data; and represent and interpret data in pictograms, bar charts, line graphs, and pie charts and solve related problems.

Science Curriculum in Primary and Lower Secondary Grades

The science curriculum that was in effect for students tested in TIMSS 2011 was the Integrated Curriculum for Primary School from 2003. This science curriculum was designed to provide opportunities for students to acquire scientific knowledge and skills, develop thinking skills, and apply this knowledge and skills in everyday life. It also was designed to instill scientific attitudes and noble values, which should be integrated into every learning activity.[10] In addition, learning activities should be directed toward activating students' critical and creative thinking skills and not confined to routine or rote learning. Thus, at this level, the curriculum is organized around three learning areas: Scientific Knowledge, Skills, and Scientific Attitudes and Values.

- Scientific Knowledge—Encompasses interrelated concepts, facts, rules, or principles associated with biological, chemical, and physical processes as well as astronomy and technology.
- Skills—Scientific and thinking skills are utilized in science because of the emphasis on inquiry and problem solving. Scientific skills are important in scientific investigations, such as conducting experiments and carrying out projects. Enhancing students' thinking ability is one of the objectives of the national education system; therefore, the curriculum emphasizes thinking skills as a foundation for thoughtful learning.
- Scientific Attitudes and Values—Scientific attitudes and noble values are instilled through science learning experiences, spontaneously or through planned activities.

Upon completing Grade 4, students will have studied living things and nonliving things. Students learn about themselves, animals and plants, and the life processes of humans and animals and how living things survive. They also learn about physical quantities—light, heat, sound, energy, magnets, and electricity—and their measurement. Students learn about man-made and natural materials and their properties. At this stage, students also study the solar system and the development of technologies in agriculture, communication, transportation, and construction.

In lower secondary school (Grades 7–9), the aim of the science curriculum is for students to develop literacy in science and technology as it relates to everyday life. By gaining scientific knowledge, skills, and values, students should be able to solve problems and make decisions that improve quality of life. The learning activities at the lower secondary level focus on developing students' critical and creative thinking, problem-solving skills, and entrepreneurship.

The lower secondary science curriculum is organized into six content areas: Scientific Method, Biology, Physics, Chemistry, Technology and Sustainable Living, and Earth Science and Astronomy. The science topics taught for each content area are presented in Exhibits 1–6.

Exhibit 1: Scientific Method Topics, Grades 7–9

Main Topics
Understand that science is a part of life; describe the importance of innovation in technology; describe the steps in a scientific investigation; become familiar with units of measurement, measuring tools, and derived units (e.g., density).

Exhibit 2: Biology Topics, Grades 7–9

Main Topics	Sub-topics
Cells as a Basic Unit of Life	Understand that cells make up all living organisms (unicellular and multicellular) and identify the cell's structures and functions (nucleus, cytoplasm, mitochondria, chloroplasts, cell membrane, and cell wall); know that the nucleus contains chromosomes that consist of DNA; list the physical characteristics inherited from parents' cells; compare and contrast animal and plant cells; understand the types and functions of human cells (nerve, epithelium, muscle, reproductive, blood, and bone); and arrange cells in order from simple to complex.
Reproduction	Compare and contrast sexual and asexual reproduction, identify the structures and functions of the male and female reproductive systems, compare and contrast male and female gametes, and describe fertilization; explain the menstrual cycle and relate the fertile phase to fertilization; identify the location of fertilization and the implantation of the embryo; explain the importance and functions of the placenta and umbilical cord and the development of the zygote and embryo; describe factors that influence the physical and emotional development of a baby; discuss breast feeding; discuss the negative consequences of unwanted pregnancy; explain sexually transmitted diseases; discuss the importance of research in human reproduction; describe human growth and development; describe the functions of the male and female reproductive parts of a flower in sexual reproduction, describe pollination, and relate the characteristics of flowers to their agents of pollination; and compare and contrast self-pollination and cross-pollination and explain the advantages of cross-pollination in agriculture.
Sensory Organs	Relate each sensory organ to its stimuli; identify the structures and locations of sensory cells used to detect smell and taste; identify the structure of human skin; identify, draw, and label the structures of the ear and discuss the hearing mechanism; and identify structures of the eye and their functions.
Digestive System	Identify classes of food and their functions; identify parts of the digestive system and their functions; describe the process of digestion; explain absorption of the products of digestion; explain reabsorption of water in the large intestine; relate defecation to eating habits; and discuss the importance of eating nutritious food.
Circulatory System	Describe respiration; explain the gases exchanged at the alveoli; explain the effect of smoking and exposure to second-hand smoke; draw and label parts of the heart; and differentiate blood vessels, oxygenated and deoxygenated blood, and justify the importance of a healthy heart.
Excretory System	Describe the excretory systems of humans and plants; explain the importance of healthy kidneys; relate photosynthesis, transpiration, and respiration in plants; and generate ideas about how to use the excretory products of plants.
Interdependence among Living Organisms and the Environment	Discuss the importance of interactions among living organisms and the environment; explain steps taken to preserve and conserve living organisms; and predict consequences of rapid human population growth.

Exhibit 3: Physics Topics, Grades 7–9

Main Topics	Sub-topics
The Principle of Conservation of Energy	Explain the principle of conservation of energy; identify changes of energy forms; explain the concept of energy efficiency and suggest steps to increase energy efficiency.
Heat	Explain the effects of heat on matter; use hands-on activities to explain the method of heat flow from hot to cold areas (conduction, convection, and radiation); design innovative ways to save energy; and explain how animals regulate their body temperature by using physical characteristics and behavioral patterns.
Sound	Define sound; relate the properties of sound to its characteristics (loudness, amplitude, pitch, and frequency); use hands-on activities to explain how sound is transferred through a medium; use hands-on activities to explain sound reflection and absorption and their application in everyday life.
Light	Identify the properties of light; draw a ray diagram to show the reflection of light from a plane mirror and state the properties of the image formed; draw a ray diagram to show the refraction of light through media of different densities; prove that white light consists of seven colors; and build optical devices using plane mirrors.
Air Pressure	Explain and give examples of things that use the principle of air pressure; generate ideas that use the principle of air pressure to solve problems; and create models that use the principle of air pressure.
Force	Explain various types of forces and their effects; describe frictional force and explain the application of friction in everyday life; and describe and solve problems using the concepts of work and power.
Electricity	Describe electrostatics; compare and contrast circuits with components in parallel and series; explain magnetism and electromagnets; compare and contrast a step-up transformer and a step-down transformer and their applications in everyday life; describe how electricity is generated and distributed; describe wiring and safety precautions used with electricity; and describe ways to conserve electricity and why conservation is important, and predict problems Malaysia would face if there was a shortage of electricity.

Exhibit 4: Chemistry Topics, Grades 7–9

Main Topics	Sub-topics
Matter	Describe matter; prove that living and non-living things have mass and occupy space; describe the four states of matter; describe the periodic table; compare and contrast the properties of metals and non-metals; describe the physical methods of separating mixtures (filtration, distillation, magnetic separation, sedimentation, floatation, and chromatography); and explain the conservation of mass during chemical changes; and recognize that compounds can be separated chemically.
Air	Explain the importance of oxygen, carbon dioxide, nitrogen, and inert gases in everyday life; explain how the percentage of gases in the atmosphere is maintained through the oxygen–carbon cycle; predict the consequences on Earth when the oxygen–carbon cycle is out of balance; describe the effects of air pollution on living things and the environment; and suggest the steps needed to control air pollution.

Main Topics	Sub-topics
Water and Solutions	Determine the composition of water; compare and contrast evaporation and boiling; describe applications of water evaporation in daily life; explain factors that affect the solubility of solutes in water; explain the importance of water as a universal solvent; describe neutralization and give examples to explain the applications of neutralization in daily life; describe various types of water purification; describe how the water supply system works; explain ways to conserve water; explain the effect of water pollution on living things; and discuss ways to control water pollution and preserve water quality.
Reactivity of Metals	Determine the reactivity of metals and explain the process of extracting a metal from its ore.

Exhibit 5: Technology and Sustainable Living Topics, Grades 7–9

Main Topics	Sub-topics
The Support System	Explain the skeletal system in vertebrates and the various support systems in invertebrates; compare and contrast the strength of hollow and thick bones; and discuss the importance of the support system to living things.
Simple Machines	Describe levers and pulleys and their functions; and solve problems using the principles of levers and pulleys.

Exhibit 6: Earth Science and Astronomy Topics, Grades 7–9

Main Topics	Sub-topics
Earth Structures	Describe fossils and their formation; discuss the importance of fossils to modern science; describe rock formations and the uses of igneous, metamorphic, and sedimentary rocks; recognize that the Earth's structure consists of the lithosphere, hydrosphere, and atmosphere; explain the distribution of organisms in the hydrosphere; and describe the layers in the atmosphere and their functions.
Astronomy	(Solar System) compare and contrast the solar system models used by Ptolemy, Copernicus, and Kepler; describe the nebular theory of the formation of the solar system; and compare and contrast the eight planets in the solar system; (Stellar Astronomy) describe how the sun generates its power; describe the birth and death of a star; and explain how solar wind and the phenomena on the sun's surface affect life on Earth; and (Cosmology) describe the galaxies and the universe and discuss the importance of space exploration.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

At the primary level (Grades 1–6), students study mathematics for seven 30-minute periods per week, while at the lower secondary level (Grades 7–9), they study the subject for five 40-minute periods per week. In Grades 1–3, students study science for three 30-minute periods per week, and in Grades 4–6, they study the subject for five 30-minute periods per week. At the lower secondary level, five 40-minute periods per week are devoted to science instruction.

Instructional Materials, Equipment, and Laboratories

Schools are given autonomy to determine teaching approaches and strategies. The curriculum specifications for both science and mathematics, however, do provide suggested teaching and learning activities to help teachers plan and implement more effective instruction. Science lessons at the primary level are carried out in science classrooms, while proper laboratories are provided in secondary schools (some schools also have mathematics classrooms). The ministry provides annual grants to schools (on the basis of enrollment) for the purchase of equipment, chemicals, teaching aids, and materials needed for mathematics and science, which schools then purchase directly. The ministry also regularly supplies any necessary general resources.

Use of Technology

Technology is integrated into science teaching and learning to enable students to explore and develop their understanding of mathematical and scientific concepts. Technology tools such as calculators, computers, educational software, and the Internet are used for independent or group work.

Communication, collaboration, problem solving and decision-making are some of the skills required in the 21st century. Online collaborative platforms enable information sharing as well as collaboration on group projects among students of different schools, communities, and cultures, both within Malaysia and in other countries. For example, Oracle's ThinkQuest is a collaborative platform in which students can work on group projects in science and mathematics, and where completed projects can be shared online. Students also use social platforms such as Facebook, Yahoo Groups, and Google to communicate and collaborate on science and mathematics topics. In addition, instructional materials developed by teachers and shared on YouTube, SlideShare, and other platforms have been used in the classroom.

EduwebTV, a platform managed by the Ministry of Education, also is available to teachers for downloading videos related to the curriculum, news, and instructional materials, as well as for uploading their own materials for sharing. Virtual Learning Environments (VLE) is a learning management system that also can be used to deliver instructional materials to students for individualized learning. For example, VLE can be used to deliver Sharable Content Object Reference (SCORM) e-learning materials online, including assignments that teachers can score and record within the system.

In Malaysian education, there is a focus on user-generated content, which means that teachers develop customizable content suited to their students' learning needs. The Ministry of Education trains information technology coordinators and library media specialists (ICT lead users) to develop content, using software such as Microsoft PowerPoint and Movie Maker, which can be shared on EduwebTV or other collaborative platforms. ICT lead users then train teachers in their schools to develop and share content. Teacher Communities of Practice (COP) use online collaborative platforms to share ideas, best practices, instructional materials, and lesson plans, in order to enable other practitioners to learn from one another and to improve their teaching.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Specialist teachers in mathematics and science teach these subjects at the primary, lower secondary, and upper secondary levels.

Homework Policies

There is no homework policy in the Malaysian educational system. Nevertheless, assigning homework is a common practice in all schools.

Teachers and Teacher Education

Teaching in Malaysia is a dynamic profession, and education plays a pivotal role in nation building. The National Education Philosophy and Teacher Educational Philosophy serve as the blueprints for creating resilient, professional, and technologically competent teachers who meet world-class standards. These philosophies encompass aspects of education as well as teachers' ongoing professional development. In a continual quest for excellence, the ministry has upgraded its teacher education colleges throughout the country to teacher education institutes so that they can confer teaching degrees. This coincides with the ministry's efforts to upgrade and improve the teaching profession as a whole and, specifically, to enhance teachers' competence and professionalism. As teaching becomes a graduate profession in Malaysia, professional teacher education soon will become a reality for both primary and secondary school teachers.

Currently, teacher education programs include a postgraduate teaching course (1-year), bachelor of education twinning programs (collaborative arrangements, whereby a local college contracts to teach the first and often the second year of classes of a partner university located abroad), bachelor of education degree courses (5 ½ years), and a study abroad degree program.

Teacher Education Specific to Mathematics and Science

Teacher education institutions and public universities are responsible for teacher education, under the purview of the Ministry of Higher Education. Currently, Malaysia has 27 teacher education institutes and an English Language Teaching Center. The ministry uses stringent admission criteria to ensure that only qualified candidates enter the profession. Education program candidates are chosen through the Malaysian Teachers Selection Test, individual and group interviews, and a written English test. Candidates applying for the postgraduate teaching program of study in their area of specialization have additional requirements.

Candidates who study the mathematics option must complete a degree in mathematics in addition to passing the Malaysia Certificate of Education examination to gain a distinction in Additional Mathematics.

Requirements for Ongoing Professional Development

Professional development programs in mathematics and science include the following: a one-year specialist teacher course; postgraduate programs; fourteen-week professional development courses; a degree program for non-graduate teachers; degree programs for foreign language teachers; professional upgrading courses for teachers in indigenous schools, remote schools, and Smart Schools (ICT-focused schools); and a Malaysian educator development program.[11] Mathematics and science professional development programs provide teachers with a sound foundation in subject matter knowledge, pedagogical skills, information technology, and moral values. The goal of these programs is to produce knowledgeable and skillful teachers who are capable of quality teaching and effective delivery of the curriculum, using an experiential learning process that enables the teacher to become a facilitator rather than an information provider. Overall, the national education policy aspires to produce a group of professionals who can meet the current needs of a changing education system that faces the challenges of globalization.

The Teacher Education Division and Aminuddin Baki Institute are responsible for both in-service teacher training and professional development programs, including those in mathematics and science.

Monitoring Student Progress in Mathematics and Science

The primary purpose of examinations in Malaysia is to determine student achievement, which indirectly determines the effectiveness of programs and teaching methods. For this purpose, tests and examinations are conducted at both the school and the national level. At school, teachers use a variety of methods to assess student achievement and other aspects of human development. Occasionally, tests are administered at the district or state level to measure academic achievement.

At the national level, Malaysia conducts five major national examinations throughout the 13 years of schooling. Two main examination bodies have been responsible for conducting national examinations in Malaysia: the Malaysian Examinations Syndicate (MES) and the Malaysian Examinations Council (MEC). MES is responsible for a number of national assessments: the Primary School Achievement Test (*Ujian Pencapaian Sekolah Rendah*), taken at the end of Year 6 (Grade 6); the Lower Secondary School Assessment (*Penilaian Menengah Rendah*), taken at the end of Year 9 (Grade 9); the Malaysian Certificate of Education (*Sijil Pelajaran Malaysia*), taken at the end of Year 11 (Grade 11); and the Malaysian Higher Religious Certificate (*Sijil Tinggi Agama Malaysia*), taken as a qualification to apply for suitable degree programs in religious studies at Middle Eastern and local universities. MEC sets and administers the Malaysian Higher School Certificate (*Sijil Tinggi Persekolahan Malaysia*, an internationally recognized pre-university examination considered equivalent to GCE A-Level by most universities).

Although student assessment is implemented in school-based and national modes, Malaysia has always relied on national examination results to make decisions on almost everything in the educational and vocational contexts, particularly selection, placement, streaming, learning opportunity, certification, and promotion. Realizing that the country's education system has become too examination-oriented, the Ministry of Education has decided to shift to a more holistic and flexible approach by de-emphasizing centralized examinations in favor of school-based assessment, which has been improved so that it can be implemented more widely at the primary and secondary school levels. The objective is to provide a set of indicators and subsequent tests to assess students' potential, development, and learning readiness, in addition to their traditionally assessed level of achievement.

To accomplish the Malaysian concept of holistic assessment, MOE plans to take the following actions:

- Reduce over-reliance on national examination data about students in the school system;
- Empower schools and teachers to conduct quality assessment of their own students, recognizing and acknowledging existing school assessments;
- Combine data from school-based and central-based assessments;
- Extend the scope of assessment to include other fields, such as student involvement in co-curricular and other activities related to the humanities and character building;
- Introduce psychometric assessment as a method to collect data and information about student psychological traits, in order to enable teachers to better understand and facilitate student learning;
- Introduce and implement standards-referenced assessment to ensure that the performance of Malaysian students aligns with accepted world standards in various areas of knowledge, skills, and competence; and
- Increase collaboration with various agencies and stakeholders in the process of assessment, education, and certification.

This reconceptualization of educational assessment has led to the creation of the National Education Assessment System (NEAS). To collect more holistic information about a student's profile, involvement, development, and achievement, NEAS will implement five types of complementary assessment methods: School Assessment; Central Assessment; Psychometric Assessment; Central Examination; and Physical, Sports, and Co-Curricular Activity Assessment. Teachers are already familiar with these methods, with the exception of Psychometric Assessment.

- School Assessment—This method is any form of assessment that is planned, developed, conducted, examined, and reported by teachers in the school and that involves students, parents, and other individuals. With the introduction of norm-referenced assessment, performance standards and scoring rubrics are used instead of the usual numerical scores or grades. Beginning in January 2011, performance standards have been used for the school assessment of Year 1 (Grade 1) students. This practice was extended to Year 2 (Grade 2) and Year 7 (Grade 7) in 2012.
- Central Assessment—This method is any form of assessment whose standards, instruments, data analysis, and guidelines are provided by the

Malaysian Examinations Syndicate (MES) but whose administration, marking, and reporting are conducted by schools.

- Psychometric Assessment—This method refers to any assessment activities used to identify students' psychological traits or innate abilities related to their learning: general abilities, aptitudes, personalities, strengths, weaknesses, talents, interests, preferences, attitudes, and inclinations. The information from psychometric assessment enables teachers to understand their students, parents to understand their children, and students to understand themselves.
- Central Examination—This method is any examination that is developed, scheduled, conducted, examined, and reported by MES. A student's performance in the central examination is reported in a results statement or certificate that MES awards after also considering the student's performance on the school assessment and central assessment.
- Assessment of Physical, Sports, and Co-Curricular Activity Assessment—This method is an assessment of student involvement, participation, and performance, in various co-curricular and extra-curricular activities. These physical activities can be any form of outside-the-classroom activities such as physical education, sports, athletics, and games. Co-curricular activities are the activities conducted by an association, club, or a uniform group, such as the Boy Scouts or Girl Guides.

The central goal of NEAS is to transform assessment from a judgmental role to one of monitoring student growth and development. NEAS is not a replacement for examinations, but rather a complementary extension of the present system. It provides guidance on how schools can assess their students more holistically and fairly. Consequently, it enables schools to create a database of students' cognitive, affective, and psychomotor development and performance in different educational dimensions, as well as these students' readiness to venture into the fields of their choice.

Literacy and Numeracy Screening (LINUS) is a remedial program designed to ensure that students acquire basic literacy and numeracy skills after three years of primary school. Implementation began in the spring of 2010 and the program will be fully implemented by the end of 2012. With LINUS, screening instruments are administered by schools three times a year to identify students in Years 1–3 (Grades 1–3) who have problems in reading, writing, and arithmetic, based on a set definition of literacy and numeracy skills. The first screening test was conducted in March 2010 for all Year 1 (Grade 1) students. Students who do not achieve a certain standard or requirement are placed in the LINUS program.

Impact and Use of TIMSS

Trend information in TIMSS 2007 has been used by the Malaysian Ministry of Education to make decisions about investment in education, curriculum reform, and initiatives to improve instruction in mathematics and science. Secondary analyses of TIMSS 2007 Malaysian data have been used to investigate student performance, especially in relation to the TIMSS assessment frameworks as well as student backgrounds and attitudes. Regarding current curriculum revision, TIMSS cognitive domains will be incorporated into mathematics and science curricula, and syllabi will be revised to reflect the TIMSS frameworks. Decisions will be made regarding these curricula in the 2015–16 school year.

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Malta

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Introduction

Overview of the Education System

The Ministry of Education and Employment (MEDE) is responsible for education in Malta, and equity and quality underscore the government's education policy. Commitment to these principles is evidenced by inclusivity at all levels and the provision of free public school education to all, from kindergarten to the tertiary level. The government also subsidizes church schools that do not charge tuition fees, and gives tax rebates to parents who send their children to private schools.

The Education Act of 1988 is the legal framework regulating education provision in Malta.[1] A 2006 amendment to the Act established two directorates: the Directorate for Educational Services (DES) and the Directorate for Quality and Standards in Education (DQSE). DES plans, manages, and provides resources and services to state schools, while DQSE establishes and monitors standards as well as quality of programs and services provided in both state and non-state schools. The amended Education Act further decentralized decision-making by forming college networks in the state sector.[2] Currently, there are ten college networks in Malta, each with its own legal and distinct identity and consisting of multiple preprimary schools, primary schools, and at least two secondary schools.

DQSE also is responsible for formulating, implementing, and monitoring the curriculum. In 1999, DQSE published *National Minimum Curriculum* (NMC), the curriculum currently used in Malta. In 2008, a review of NMC began and the new draft, *Towards a Quality Education for All: The National Curriculum Framework,* was published in May 2011. The publication was subject to an eight-month consultation process that culminated in a national conference in December 2011. Currently, feedback is being analyzed and work is being carried out to finalize the *National Curriculum Framework* in 2012 for implementation beginning in the 2012–13 school year.

Compulsory education covers ages 5–16 and comprises two main cycles: primary education (ages 5–11) and secondary education (ages 11–16). Prior to the start of primary education, there is provision for child daycare (ages 0–3) and kindergarten (ages 3–4). Although preprimary education is not compulsory, approximately 98 percent of four-year-olds attend kindergarten.

Parallel to the public education sector there is a non-state sector (comprised of church and independent schools) that educates approximately 40.8 percent of students. The two sectors work in close partnership to provide a quality education to all students. All primary schools are co-educational, while state and church secondary schools are single sex.

Following compulsory education, students can choose to follow either a general or vocational education path. Tertiary education is provided at the University of Malta and at the Malta College of Arts, Science, and Technology, with the latter specializing in vocational degrees. State educational institutions as well as private providers offer lifelong learning courses for adults during the day or in the evening. Some courses are run in collaboration with local councils to facilitate accessibility to adult learners. Courses cover a wide array of subjects and topics, and can be used to acquire formal qualifications or for personal self-development.

Languages of Instruction

At the end of 2010, the total population in Malta was approximately 417,000, with 95 percent being Maltese. Malta has two official languages: Maltese, the national language, and English. The National Minimum Curriculum (NMC) regards bilingualism as the basis of the education system, defining bilingualism as the effective, precise, and confident use of the country's two official languages. Students must be functionally bilingual by the end of their entire schooling experience. NMC encourages teachers at the primary level to use English when teaching English, mathematics, science, and technology. At the secondary level, the curriculum requires Maltese and English subjects to be taught in their respective languages, and recommends that foreign languages be taught in those languages. Teachers of social studies, history, religion, and personal and social education teach these subjects in Maltese, while other subjects are to be taught in English.

In view of these recommendations, classroom teachers decide what language will facilitate students' development and acquisition of mathematical concepts. Once this objective is achieved, it is essential that students be exposed to mathematical ideas in English and listen to adults correctly using mathematical vocabulary. However, on no account should the use of either language (Maltese or English) be to the detriment of students learning mathematics content.

Instruction in science is provided in English. However, in the majority of cases (especially in state schools), English is the students' second language, which can create challenges related to proper understanding of concepts.

Mathematics Curriculum in Primary and Lower Secondary Grades

Mathematics is an important tool by which information can be organized, manipulated, and communicated. It also is an ever-expanding body of facts, skills, concepts, and strategies used to solve a wide range of problems. Consequently, when implementing the syllabus, mathematics teachers should emphasize both the utilitarian and aesthetic aspects of mathematics.[3]

- Utilitarian Aspect—Mathematics is useful, equipping learners with the necessary knowledge to help them understand and interact with the world around them.
- Aesthetic Aspect—Mathematics is a beautiful subject with an evolving body of knowledge that is characterized by order, precision, conciseness, and logic.

In mathematics instruction, teachers should ensure that students do the following:

- Understand and appreciate the role and purpose of mathematics in culture and society, in the past as well as the present;
- Apply mathematical knowledge and understanding to solve a wide range of standard and non-standard problems, ideally from real life situations;
- Think and communicate mathematically (i.e., precisely, logically, and effectively);
- Develop a positive attitude toward mathematics that fosters creativity, confidence, perseverance, and enjoyment of the subject;
- Develop the ability to work both independently and cooperatively when doing mathematics;

- Acquire a secure foundation for the further study of mathematics;
- Appreciate the interdependence of the different branches of mathematics;
- Appreciate the interdisciplinary nature of mathematics and its use in other areas of knowledge; and
- Make efficient, creative, and effective use of appropriate technology in mathematics.

The mathematics curriculum comprises a list of objectives for each year in the primary and secondary years. Each list is divided into four strands—Number; Algebra; Shape, Space, and Measure; and Data Handling—and students are expected to achieve specified attainment levels within each strand.

At the primary level, there are three attainment levels—Levels 4, 5, and 6—while at the secondary level there are four attainment levels—Levels 7, 8, 9, and 10.[4] Each attainment level between Levels 4 and 8 (inclusive) spans two academic years. Level 9 is covered in one year, while Level 10 is aimed at gifted students. Attainment Levels 1, 2, and 3 are meant for students with special needs. If students are above or below the expected level, adjustments are made accordingly. Exhibit 1 presents each attainment level along with its corresponding academic year and age range.

Exhibit 1: Curriculum Attainment Levels with Corresponding Year and Age Ranges

Sector	Attainment Level	Number of Academic Years	Ages
Primary	Level 4	Years 1–2 (Grades 1–2)	5–7
Primary	Level 5	Years 3–4 (Grades 3–4)	7–9
Primary	Level 6	Years 5–6 (Grades 5–6)	9–11
Secondary	Level 7	Forms 1–2 (Grades 7–8)	11–13
Secondary	Level 8	Forms 3–4 (Grades 9–10)	13–15
Secondary	Level 9	Form 5 (Grade 11)	15–16
Secondary	Level 10	Gifted Students	15–16

Because students in Malta were assessed at the fifth grade (Level 5), Exhibit 2 presents the learning objectives within the four mathematics curriculum strands for the later primary attainment levels covering Grade 5, and the initial portion of Grade 6 (Level 6).

Exhibit 2: Later Primary (Grade 5) Mathematics Learning Objectives

Strand	Attainment Level	Students are able to
Number	Level 5	Read, write, and use numbers up to at least 1,000;
		Identify place value in four-digit numbers and round two- and three-digit whole numbers to the nearest 10 or 100;
		Add and subtract two- and three-digit numbers mentally and using informal pencil and paper procedures (including column addition);
		Count in 100s and identify odd and even numbers to at least 100;
		Develop an understanding of multiplication as "repeated addition" and as an array, and understand and apply the zero and commutative properties of multiplication;
		Develop an understanding of division as "grouping," "repeated subtraction," and "sharing," with and without remainders;
		Recall multiplication facts for the 2, 3, 4, 5, 8, and 10 times tables, and derive division facts corresponding to the 2, 3, 4, 5, and 10 times tables; and
		Identify fractions and equivalent forms of simple fractions, understand mixed numbers, compare and order fractions, position fractions on a number line, make estimates, and solve and complete practical tasks and problems involving fractions.
	Part of Level 6	Use written methods to add and subtract two or more numbers less than 1,000 involving decimals;
		Understand decimal notation for tenths and hundredths, round numbers with one or two decimal places to the nearest integer, and order numbers with up to three decimal places;
		Multiply and divide decimals by 10 and 100 and integers by 1,000 and explain the effect, and use written methods to multiply or divide a three-digit by a two-digit integer;
		Find simple common multiples and factors and apply simple tests of divisibility;
		Recognize odd and even numbers up to 1,000, square numbers and triangular numbers;
		Understand fractions, find fractions of numbers or quantities, reduce a fraction to its simplest form, and solve problems; and
		Solve simple problems involving proportion, understand percentage as the number of parts in every 100, and find simple percentages of small whole-number quantities.
Algebra	Level 5	Identify patterns in number from 0 to 1,000;
		Count in 4s or in 100s and recognize odd and even numbers to at least 100;
		Describe (identify the rule in) and extend simple number sequences;
		Understand that the same quantity can be written as an addition or a subtraction expression (e.g., 24 = 20 + 4 or that 24 = 30 – 6) and understand the relationship between addition and subtraction, and provide a subtraction statement corresponding to a given addition statement, and vice versa;
		Understand the principles of the commutative, associative, and distributive laws of multiplication;
		Recognize that division is the inverse of multiplication, and that halving is the inverse of doubling;
		Solve number sentences in one or two unknowns and translate a word problem into a number sentence; and
		Solve mathematical puzzles by recognizing patterns and relationships and suggest extensions.

Strand	Attainment Level	Students are able to
Algebra	Part of Level 6	Develop the idea of continuity and understand that the number line is continuous; Solve inequalities; Extend number sequences, such as sequences of square numbers and triangular numbers; Understand and use the relationships between the four arithmetic operations and the principles of arithmetic laws; Factor numbers and use partitions (e.g., 87 x 6 = (80 x 6) + (7 x 6)); Identify properties and rules regarding brackets and order of operation; Check results of calculations with an equivalent calculation or with the inverse operation; Translate more difficult word problems into number sentences and equations; and Draw graphs to display factual information, show mathematical relationships, and describe them in their own words.
Shape, Space, and Measure	Level 5	Identify, describe, and sort two-dimensional and three-dimensional shapes referring to properties such as symmetry, the number or shape of faces, the number of sides or edges and vertices, whether sides or edges are the same length, and whether or not angles are right angles; Recognize that a straight line is equivalent to two right angles and compare angles with a right angle; Identify and sketch lines of symmetry in simple shapes, sketch the reflection of a simple shape across a mirror line along one edge, and recognize shapes with no lines of symmetry; Recognize and use the four compass directions and make and describe right-angled turns; Estimate measures (to the nearest whole- or half-unit or in mixed units) and compare lengths (km, m, cm), masses (kg, g), and volumes (l, ml) using standard units, and suggest units and equipment for such measurements; Read simple scales to the nearest division, including using a ruler to draw and measure lines to the nearest centimeter; and Use units of time (second, minute, hour, day, week, month, and year), know the relationship between them, read a calendar, suggest suitable units to estimate and measure time, and read the time to five minutes on an analogue clock and a 12-hour digital clock.
	Part of Level 6	Classify triangles (isosceles, equilateral, scalene) referring to sides, angles, and lines of symmetry and draw shapes with increasing accuracy; Visualize three-dimensional shapes from two-dimensional drawings and identify different nets of solid shapes; Recognize symmetry in regular polygons, complete symmetrical patterns with two lines of symmetry at right angles, and recognize the position of a shape after reflection across a mirror line; Identify, estimate, and order acute and obtuse angles, use a protractor to measure and draw these angles, and check the sum of angles in a triangle and on a straight line; Use the eight compass directions and make and measure clockwise and counter-clockwise turns; Know and use the relationships between familiar units of length, mass, and volume and make estimations in relation to everyday situations; Understand perimeter and area of rectangles and other simple shapes (including compound shapes); and Use timetables and read the time on a 24-hour digital clock and use notation for 24-hour time.

Strand	Attainment Level	Students are able to
Data Handling	Level 5	Read and interpret numerical data in lists, charts, frequency tables, pictograms, bar charts, and line graphs, and construct them;
		Use scales on charts and graphs and understand intervals;
		Collect, organize, and represent data to solve problems and complete practical tasks; and
		Use appropriate language such as "least common," "most common," "most favorite," and "least favorite" to discuss and explain results.
	Part of Level 6	Solve problems by representing, extracting, and interpreting data in lists, tables, charts, graphs, pictograms, and diagrams, including those generated by a computer;
		Construct and use charts, graphs, tables, and pictograms;
		Perform experiments such as tossing a coin or rolling a die, record outcomes and construct frequency charts, graphs, and tables;
		Decide how best to organize and present findings (including use of ICT where appropriate), and use precise mathematical language and vocabulary when discussing data;
		Answer questions by collecting, selecting, and organizing relevant data, draw conclusions, and identify further questions; and
		Explore and calculate the mean of a simple set of data.

Exhibit 3 presents the learning objectives for the lower secondary attainment levels covering eighth grade (Level 7 and part of Level 8) within the four mathematics curriculum strands.

Exhibit 3: Lower Secondary (Grade 8) Mathematics Learning Objectives

Strand	Attainment Level	Students are able to
Number	Level 7	Use the four arithmetic operations (addition, subtraction, multiplication, and division) for calculating with integers, fractions, and decimals, including the correct order of operations and the use of brackets;
		Use ratios to compare two or more quantities, find the percentage associated with a quantity, and find the percentage increase or decrease;
		Understand and use positive exponents to represent squares and cubes and understand and use prime numbers, prime factors, the least common multiple, and greatest common factor; and
		Use basic functions of a scientific calculator, round numbers to a specified number of decimal places, and carry out rough estimates.
	Part of Level 8	Reverse percentage changes and understand and calculate simple interest;
		Solve problems involving direct and inverse proportions;
		Apply the four arithmetic operations to mixed numbers and understand reciprocals;
		Work with numbers in standard form and round numbers to a specified number of significant figures; and
		Use the number line to illustrate inequalities.
Algebra	Level 7	Understand the use of letters to represent unknown values, simplify algebraic expressions by collecting like terms, multiplying a single term over a bracket, and taking out a common factor;
		Construct and solve linear equations in one unknown; understand that the equation of a straight line describes the relationship between the x and y coordinates, generate ordered pairs, and plot them;
		Draw and use graphs to convert between units; and
		Generate terms of a sequence.

Strand	Attainment Level	Students are able to
Algebra	Part of Level 8	Simplify fractions, factor expressions, and expand expressions written in factored form;
		Solve linear and simultaneous equations in two unknowns by trial and error;
		Understand and determine the nth term of a sequence;
		Write and manipulate more complex formulae;
		Understand, interpret, and calculate the slope of a line and identify the slope and intercept in a linear equation;
		Solve systems of two linear equations graphically; and
		Draw and use quadratic graphs to identify maxima and minima and solve quadratic equations and related problems.
Shape, Space, and Measure	Level 7	Use a protractor to measure and draw angles up to 360° and solve problems involving basic angle facts, including parallel lines;
		Use bearings to describe direction;
		Draw basic constructions and identify geometric properties of triangles and quadrilaterals through line and rotational symmetry;
		Classify quadrilaterals using their geometric properties;
		Identify parts of a circle (center, radius, diameter, and circumference);
		Use formulas to find areas of triangles, parallelograms, and compound shapes; and
		Find the volumes of compound shapes involving cubes and cuboids, and draw translations, reflections, and rotations.
	Part of Level 8	Convert units of area and volume;
		Use angle properties of polygons and construct regular polygons;
		Understand proof and use the Pythagorean theorem;
		Calculate perimeters and areas of circles, sectors, and segments and surface areas and volumes of prisms and pyramids;
		Understand and use the three basic trigonometric ratios (sine, cosine, and tangent) and solve problems involving angles of elevation, depression, and bearing;
		Draw and interpret scale drawings; and
		Understand and prove the fundamental angle-circle theorems.
Data Handling	Level 7	Collect data using observations, surveys, and experiments;
		Understand, compute, and interpret the mean, mode, median, and range of a set of ungrouped data, compile and interpret frequency tables for ungrouped or grouped continuous and discreet data;
		Find probability by experiment and compile sample spaces; and
		Use spreadsheets to construct bar graphs and pie charts, and compute the mean and range of sets of ungrouped data.
	Part of Level 8	Find the modal class, an estimate of the mean, and the class interval in which the median lies in grouped frequency distributions;
		Understand that the probabilities of all mutually exclusive outcomes add up to 1; and
		Use frequency tables and sample spaces.

Science Curriculum in Primary and Lower Secondary Grades

The new, proposed Primary Science Framework aims to develop foundation knowledge, understanding, skills, and attitudes toward science through first-hand experience.[5] This foundation is intended to lead to a deeper, progressive understanding of scientific activity, forming a basis for further study in science at the secondary level.

The current Primary Science Curriculum is designed to implement the objectives stated in the *National Minimum Curriculum*. Objective 12 of the *National Minimum Curriculum* focuses on students having a "greater awareness of the role of science and technology in everyday life." [6] The corresponding Maltese primary science syllabus was formulated and introduced between the years 2000 and 2003. This primary science syllabus is divided into three core areas of science related to biology, chemistry, and physics—Sharing Our World, Energy, and Materials—each of which are developed into eleven specific topics.

In the early primary years (Grades 1–3), students are expected to use their senses to observe and group objects and events in their immediate environment, and to identify possible situations for scientific investigation. They use these observations to make predictions, suggest possible solutions and simple investigations, and make simple measurements. Students also conduct investigations in a group, make simple evaluations (e.g., describing whether what happened was expected), and share their procedures and findings with the class.

In the later primary years (Grades 4–6), students are expected to compare and classify objects and events in their immediate environment, use these ideas to make testable predictions, and discover ways to conduct fair tests. They also learn to select appropriate resources and instruments and use standard measurements with appropriate precision. Students gain experience organizing themselves within groups and working in teams. They record and analyze data using simple graphs and information-processing technologies to find patterns. Groups then draw conclusions reflecting the information collected, evaluate the process, and generate ideas while presenting well-reasoned, complete reports to the class.

At the primary level, geography is taught as part of the social studies program that encompasses history, social studies, and geography. The geography program aims at making students aware of the different influences on Maltese society, using the nation's Euro-Mediterranean background as a starting point to a broader and more global perspective. It is expected that by the end of primary education, the majority of students will have attained Level 4 in the compulsory program for geography.

- Level 1—Students become aware of the immediate local environment (the classroom, the local town, or village) through oral expression and by observing natural life cycles, including day and night and the seasons.
- Level 2—Students become aware of the physical and human elements in their immediate surroundings through oral and artistic expression and some basic writing. Students are encouraged to reason and express their views about daily life events, including the weather.
- Level 3—Students become aware of the physical and human elements in Malta, the Mediterranean, and the world. These include physical and environmental features that encourage and support basic geographical research.
- Level 4—Students are able to give explanations of many of the physical characteristics of the Maltese islands through oral and written expression, as well as through pictures and maps. Emphasis is placed on the contrasts between the Maltese environment and that of other Mediterranean countries. The collection of geographical data and its presentation forms the basis for a geographical study carried out in school. Simple map interpretation and the use of photos and technological support are used for data collection.

The *Integrated Science Curriculum* for secondary education builds on the Primary Science Framework, thus students learn integrated science during Grades 7 and 8 (Forms 1 and 2).[7] This curriculum has three strands: Life Processes and Living Things, Materials and Their Properties, and Physical Sciences.

- Life Processes—This strand allows students to understand and investigate life processes as well as appreciate the diversity of living things and how these interact with each other and with the surrounding environment.
- Materials and Their Properties—This strand allows students to become aware of a diversity of naturally occurring materials, particularly through inquiry and investigations, become familiar with the structures and properties of mixtures, and understand ways of processing raw materials to form new products with different properties.

- Physical Sciences—This strand allows students to understand the properties of a variety of forces existing in the universe and to investigate their effects. Consequently, students discover how interactive forces produce conversion in energy from one form to another.

Each strand is organized into a number of units.[8] Each unit comprises a number of teaching objectives, examples of teaching activities and experiences, and indicators of learning outcomes. The approach to teaching and learning science is inquiry based and student centered, and units support a constructivist approach by following the 5E model: engage, explore, explain, elaborate, and evaluate. During each session, the teacher determines the topic of inquiry or focus question to engage students' interest and curiosity. Students observe, explore, predict, plan, and conduct investigations; collect and interpret data; and give explanations. Then, students are challenged to elaborate on their understanding by linking the known with the new and by applying concepts and skills in new contexts. Students are encouraged to evaluate their understanding and competencies, and the teacher assesses areas of strength and weakness highlighted by student performance in the activity.

During the last three years of secondary education (Grades 9–11), students choose two subjects to study as core curriculum options. Students with scientific interests can opt for biology and chemistry, while physics is compulsory in Forms 3, 4, and 5 (Grades 9–11) for students attending state schools.[9, 10, 11, 12, 13, 14, 15, 16, 17] Geography is taught by specialized teachers as a separate subject in secondary schools, and students may choose the subject as a core curriculum option during the last three years of secondary education. In non-state schools, students have the option of choosing environmental studies in lieu of geography, although some schools offer both subjects. Most non-state schools offer environmental studies as an option instead of geography in Forms 3, 4, and 5 (Grades 9–11).

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Materials, Equipment, and Laboratories

Mathematics textbooks for state schools are selected by Education Officers within the Directorate for Quality and Standards in Education, in consultation with the Heads of Department and mathematics teachers. Non-state (i.e., church and independent) schools choose their own textbooks, although some opt for the same textbooks and programs adopted in state schools.

Beginning in 2001, a program was phased in at the primary level to promote the notion that children need to develop a good sense of numbers and be able to do mental calculations, not just learning facts and procedures by rote. To accomplish this, children need a good inventory of number facts and mathematical relationships as well as good mental mathematics strategies. The program is based on the Abacus Programme, and thus takes advantage of specific instructional materials, including a mental warm-up activities book, teacher cards, textbooks, photocopy masters, a numeracy support book, and an assessment book.

At the secondary level, mathematics instruction emphasizes the utilitarian and aesthetic aspects of mathematics (described previously). Instructional materials include the following: a student textbook, detailing the main activity for each lesson; a practice book, with examples for further practice; and a teacher resource pack, with a set of notes and discussion points for each lesson.

At the primary level, there are no science textbooks; teachers provide their own learning resources to students, supplemented by resources produced by science peripatetic teachers (described in the Grade at Which Specialist Teachers for Mathematics and Science are Introduced section, below). To make the students' science learning experience interesting and enjoyable, various materials, apparatuses, and other resources are provided on an on-loan basis by primary schools and the Science Centre, a resource center for science teaching at both the primary and secondary levels. There are no laboratories in primary schools and practical lessons are carried out in class, in a science and technology room, or in a multi-purpose room.

At the secondary level, students are provided with a textbook. For Forms 1 and 2 (Grades 7 and 8), the textbook covers integrated science, while for the final three years (Grades 9–11), it covers physics, which is the compulsory science subject. Those students opting for chemistry or biology are provided with textbooks for these subjects. Teachers produce their own teaching and learning resources very often in collaboration with their colleagues in the same school. Each secondary school has a number of science laboratories in which students carry out inquiry-based learning. These laboratories have recently been re-equipped with new science apparatuses, including data loggers. Because the number of students per practical session in a laboratory cannot exceed sixteen, classes are divided into smaller groups for these sessions. Laboratory technicians are present to prepare the apparatus and to assist the teacher during the practical session. Sessions are held over two consecutive lessons so that students can have enough time to conclude their experiments.

Use of Technology

Each primary classroom in Malta and Gozo (a small island in the Maltese archipelago) is equipped with four computers, a printer, and an interactive whiteboard. Primary and secondary level classroom teachers also are provided with a personal laptop so they can prepare materials at home for classroom use.

In secondary schools, computers also are found in the library and in computer laboratories. Schools have science laboratories and each is equipped with an interactive whiteboard. During science lessons, most secondary level teachers use various digital resources available on the Internet. Students are encouraged to research science topics on the Internet to supplement information provided by the teacher.

Currently, an e-learning platform is under development; once available, it will encourage a paradigm shift in the teaching and learning experience in Maltese schools. Teachers and students then will be able to access teaching and learning resources through the e-platform.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Students are taught by specialist teachers as soon as they begin secondary education. At the secondary level, all science teachers have specialized in the teaching of one or two science subjects during their initial teaching education. Similarly, secondary level mathematics teachers have specialized in the teaching of mathematics and another related subject.

At the primary level, science teaching is carried out mainly by primary science peripatetic teachers who travel among multiple schools. Peripatetic teachers are assigned to a group of schools within a college and operate from the Science Centre. The first team of peripatetic teachers was formed back in 1990 when science was introduced in primary schools. Today, this team comprises 22 peripatetic teachers who deliver lessons, conduct fieldwork excursions, and organize other related activities in all state colleges in Malta and Gozo.

Peripatetic teachers visit their primary school classes once every other week. In between visits, science lessons are delivered by the respective classroom teachers. The work of the “specialist” peripatetic teachers is to help children develop and strengthen their scientific skills by acquiring scientific language, observing and making scientific predictions based on these observations, carrying out investigations, gathering and interpreting data, and working in a team. The peripatetic teachers’ main duties are to do the following:

- Deliver science lessons;
- Use and promote science and technology through the use of resource boxes;
- Support primary classroom teachers in science-related teaching and learning;
- Assist schools in developing science and technology policies in their School Development Plans (SDP);
- Produce and deliver hands-on science activities outside the classroom;
- Organize and conduct fieldwork excursions; and
- Conduct an inquiry-based practical session assessment of students in Years 4–6 (Grades 4–6).

Homework Policies

Malta has no centrally prescribed homework policy for either mathematics or science; decisions regarding homework are at the discretion of the school or college. At both primary and secondary education levels, daily mathematics homework is commonly used for consolidating and reinforcing concepts. In primary grades, homework is graded daily by the teacher, usually after corrections have been carried out in class. In secondary grades, special homework is assigned after a topic is completed and is always graded by the teacher for formative purposes. In science, homework can take various forms, including research, multiple-choice items, essay writing, problem solving, and projects and presentations.

Teachers and Teacher Education

At present, there are two main forms of initial teacher education: the concurrent model, and the consecutive model. The most common option is the concurrent model, whereby students follow a four-year Bachelor of Education Honors program of study at the University of Malta, or any other recognized university, and specialize in either primary or secondary teaching. This full-time program of study comprises 240 European Credit Transfer System units (ECTSs) and includes field placements (teaching practice periods) in schools, in addition to writing and presenting a dissertation.

The B.Ed. (Hons.) primary program track prepares students to teach each of the eight subject areas in the primary curriculum: English, mathematics, Maltese, religion, physical education, science, expressive arts, and social studies. In addition, the program has a strong professional component, which includes assessment, health education, disability, literacy difficulties, environmental education, and psychosocial and legal issues. General pedagogy and interpersonal skills are emphasized in the initial years of the program.

The B.Ed. (Hons.) secondary program track allows students to deepen their subject knowledge in both content and pedagogy. Students can choose to specialize either in one of a range of subjects offered by the faculty, or can opt for double subject specialization, which is possible in most of the humanities areas. In the secondary program track, most courses are taken in other academic departments, such as mathematics or science. In addition to subject content, this track includes a strong component of pedagogy and professional issues, which include assessment, language, diversity, and sustainable development. Importance is given to developing teachers as reflective practitioners.

The second teacher education option is the consecutive model, whereby students first complete a non-education bachelor's degree from a recognized university and then follow a one-year full-time program of study leading to a Post-graduate Certificate in Education (PGCE). Teachers following the consecutive model are usually destined to become teachers at secondary level.

The PGCE program focuses on pedagogy rather than on content and emphasizes school experience together with teaching practice. Teaching practice introduces prospective teachers to the realities of classroom life and provides them opportunities to regularly plan and deliver lessons as well as to critically reflect on their own practice. All education students study educational psychology, philosophy, and sociology of education.

Teachers opting for primary education take four compulsory (ECTS) credits in teaching primary science and another four in environmental science during their first year of study. During the second year, they have two compulsory (ECTS) credits covering curriculum development in science and another two in the fourth year on teaching science. Students opting to teach at the secondary level specialize in teaching two main subjects to have more flexibility when applying for a teaching post. Education courses for both levels cover the theoretical and practical aspects of pedagogy.

Because teaching in Maltese schools is bilingual, teachers also must be proficient in both Maltese and English at the primary level. At the secondary level, prospective Bachelor of Education students pass a proficiency test in English prior to enrolling in the degree program. No teacher may obtain a permanent position if he or she does not meet the required standard in both languages.

Since the introduction of computer literacy at all levels in all schools, prospective teachers are required to possess a European Computer Driving License (ECDL) as one of the entry qualifications for a Bachelor of Education, or a post-graduate certificate or diploma in education.

Requirements for Ongoing Professional Development

All teachers, including primary science peripatetic teachers, participate in at least one In-Service Training (INSET) course related to their subject content or pedagogy per year. These continuous professional development courses, organized and conducted by the Directorate for Quality and Standards in Education (DQSE), have a minimum duration of twelve contact hours and are held either in July or September. INSET courses are open to all primary school teachers practicing in both state and non-state schools.

The following professional development sessions for teachers are organized by the directorate:

- Three 2-hour sessions (one per term) after school hours;
- Three 2-hour sessions (one per term) during school hours;
- School Development Day; and
- Three half-day INSET courses at the beginning or end of the scholastic year.

Primary science peripatetic teachers also participate as a team in a two-hour professional development or curriculum development session once every two weeks. This is an informal session held at the Science Centre to discuss pedagogical and content issues and organize training sessions when the need arises. Periodically, peripatetic science teachers voluntarily attend courses and seminars, outside normal working hours. Such courses are organized regularly by the Maltese Association of Science Educators (MASE) and the Malta Council for Science and Technology (MCST).

Monitoring Student Progress in Mathematics and Science

Evaluation of student achievement is an essential component of mathematics education. It is necessary to give teachers feedback on the success of their methods and approaches and to assist in planning for new learning (formative aspect), as well as to assess student readiness for new learning and to find out what they have learned (summative aspect). Diagnostic assessment procedures enable teachers to become aware of individual students' difficulties and plan learning activities specifically designed to meet these learning needs.

Mathematics assessment focuses both on what students know and can do and on how they think about mathematics. It involves a broad range of tasks and problems, and requires the application of a number of mathematical ideas. Assessments evaluate student skills, such as the ability to communicate findings, present an argument, and exploit an intuitive approach to a problem.

Assessment is an integral part of the normal teaching and learning program and involves multiple techniques, including written, oral, and demonstration formats. Group and team activities also are assessed periodically. Teachers avoid giving tests that only focus on a narrow range of skills, such as the correct application of standard algorithms (procedures). While these skills are important, a consequence of isolating skills and knowledge in a narrow assessment procedure is that students tend to learn only in that way. In such instances, mathematics then becomes a set of separate skills and concepts with little obvious connection to other aspects of learning or to the world.

Assessment in science reflects a similar philosophy. Science testing is based on performance task assessment principles. Students are presented with a hands-on investigative task or experiment to perform and they are assessed on the following: the manner in which they approach the task, individually and as a group; the skills they employ during the process; and the conclusions they arrive at following their investigations. During this process, students are asked to make predictions, employ fair investigative strategies, conduct multiple trials, record results, and then apply their findings to real life situations.

To provide students and their parents with information about progress, teachers report what the students have achieved and how well they achieved it. Teachers also give feedback (oral or written), indicating what the students have done well and how they can use this feedback to improve. A grade or mark alone is insufficient.

In Grades 4 and 5 (Years 4 and 5), students take school or college-based mid-year examinations and national end-of-year examinations in Maltese, English, mathematics, religion, social studies and science. In Grade 6 (Year 6, the final year of primary education), students have an examination in February and a National Benchmark for End-of-Primary in June, covering Maltese, mathematics, and English. For all the above-mentioned examinations, papers are graded to recognize different abilities.

At the secondary level, student learning is monitored by both formative and summative assessment. There are different examinations in each grade because students are tracked according to their ability level. The summative assessment process is similar to that for primary education, with a mid-year and an annual examination. At the end of secondary education, students choose to take the Secondary Education Certificate examination in the subjects they have learned. The Secondary Education Certificate covers all subjects taught in Maltese schools and is a requirement for proceeding to further education.

Impact and Use of TIMSS

Malta participated for the first time in TIMSS 2007 at Grade 8. The results obtained, especially in science, have urged policymakers to address those areas in science instruction requiring rethinking. In 2008, a working group of major stakeholders was established to review science instruction throughout compulsory education. In May 2011, a policy document entitled *A Vision for Science Education in Malta* was published and, following a broader consultation process, was finalized in December 2011. The policy recommends major changes in science education, such as introducing integrated science throughout secondary education and replacing physics as the compulsory science subject during the last three years of secondary education. It also recommends that teachers adopt a pedagogy of inquiry-based learning in their classes. The document places renewed emphasis on science instruction in primary schools, and recommends increased education in science teaching for primary school teachers.

TIMSS 2007 also has influenced the drafting of a new mathematics curriculum starting with the first year of secondary education (Form 1). To challenge the cognitive processes required for a complete learning experience, three teaching approaches are being recommended for mathematics instruction: exposition, discovery, and exploration.

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The Kingdom of Morocco

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Introduction

Overview of the Education System

The Kingdom of Morocco's 2011 Constitution specifies that the state, public institutions, local authorities and families should work toward facilitating citizens', and in particular children's, equal access to education, vocational training, physical education, and art.[1]

A number of institutions, statutes, decrees, and circulars regulate education in the country. The Ministry of National Education, Higher Education, Staff Training, and Scientific Research oversees all areas related to the provision of both public and private education. The ministry is run according to the National Charter for Education and Training adopted in 1999, which recommended decentralized education delivery and increased responsiveness to local needs and realities.[2] Accordingly, regional Academies for Education and Training in each of the 16 administrative regions of Morocco have been charged with, among other things, developing up to 30 percent of the curriculum for their respective regions to help ensure that these curricula are locally relevant. In addition, regional *Délégations* are charged with, among other things, providing services for education in their respective regions.

The implementation of the National Charter for Education and Training has resulted in renewing curricula and textbook assessment and evaluation. The National Directorate of Curricula develops the core curriculum, establishes pedagogical standards, and adopts textbooks according to the guidelines and specifications established by the ministry. These guidelines are used as a frame of reference in teacher training and the development of teaching materials.

The National Education Emergency Program was designed by the Moroccan Government with the support of development partners. The four-year program covers the period of 2009–12 and its purpose has been to accelerate the implementation of reform resulting from the National Charter of Education and Training. The specific objective of the program is to make education available to all and improve the quality of teaching and performance of the education system. The program supports the efforts of the Moroccan Government in skills development and poverty reduction under the National Human Development Initiative, as well as helping the country make significant strides toward meeting some of its UN Millennium Development Goals by 2015.[3]

Morocco's education system is divided into preprimary, primary, secondary, and tertiary education.

The National Charter of Education and Training mandates that preprimary education be available to all children between four and six years of age. Preprimary education in Morocco is provided through two types of schools: kindergartens and Quranic schools. Kindergartens, which are generally privately owned, provide education primarily in cities and towns. Quranic schools prepare children for primary education by focusing on basic literacy and numeracy skills and have always been at the forefront in the battle against illiteracy, particularly in remote areas of the country.[4] Preprimary teachers develop their own curriculum according to a set of principles established by the Ministry of Education that take into account students' physical and cognitive development, needs, interests, and abilities.[5] Attempts have been made within the framework of the National Education Emergency Program to enable primary schools to host preprimary classes with the intention that this model could be expanded in the future.

Children generally attend primary school from ages 6–12. Over the last ten years, Morocco's gross enrollment rates within primary education have been consistently rising and dropout rates have been falling. According to the National Education Emergency Support Program, many school-age children in impoverished families stay out of school due to the high cost of schooling (e.g., expenses relating to textbooks, school materials, and other incidentals), and are therefore bound to work to supplement the family income.[6] To combat educational exclusion, Morocco's government launched *Tayssir*, a conditional cash transfer program whose aim is to encourage higher primary school enrollment. *Tayssir* grants a stipend to impoverished families who enroll and keep their children in school. At the end of primary school, students must fulfill the requirements of the school leaving qualification, *Certificat d'Etudes Primaires,* to be eligible for admission to lower secondary schools.

Lower secondary school in Morocco is also compulsory. This stage lasts for three years (Grades 7–9) and is attended by children ages 13–15.[7]

Upper secondary school also lasts three years. During the first year, all students follow a common core curriculum in arts or science and technology. Following the first year, students are streamed into one of two tracks: the general and technical track, leading to the Baccalaureate, or the vocational track, leading to professional qualifications. Within the general track, first-year students study arts, science, technology, mathematics, or Islamic disciplines. Second-year students study Earth and life sciences, physics, agricultural science, technical studies, or one of two mathematics tracks (Track A in which students study Earth and life sciences, or Track B in which students study engineering sciences).

Higher education in Morocco is offered at 16 universities (*grandes écoles)* and institutes, such as Hassan II Institute of Agronomy and Veterinary Sciences. Admission is open to students who have attained the upper secondary school Baccalaureate. Many higher education institutions also require that students have minimum grades in their proposed majors and pass an entrance examination.

Languages of Instruction

According to the 2011 Constitution, Arabic and Amazigh are the two official languages of the Kingdom of Morocco. Arabic is the medium of instruction for mathematics and science at the fourth and eighth grades.

The 1999 Charter for Education and Training stipulated that an open approach toward the Amazigh language would be endorsed.[8] To this end, the Royal Institute for the Amazigh Culture (IRCAM), which was created in 2001 under provisions of the Royal Dahir, has been designing various teaching materials and teacher training programs in Amazigh jointly with the Ministry of Education. Some 12,000 teachers, 300 inspectors, and 558 school principals have so far received Amazigh teacher training through IRCAM. The inclusion of Amazigh in the school curriculum was a remarkable event within Morocco's educational spheres.

The 2011 Constitution supports learning foreign languages and stipulates that the most widely used foreign languages shall be taught as means of communication, integration, and interaction with other societies in the spirit of openness to other cultures and civilizations.[9] French, which is taught in kindergartens and the first and second grades of public primary schools, is often used as the language of government, diplomacy, technology, and economics in Morocco. French also is the medium of instruction for some technical disciplines in upper secondary schools, as well as for higher education institutes and engineering schools. English also is gaining ground as the most popular foreign second language and is used as the medium of instruction in a small number of higher education institutes and engineering schools. Spanish, Italian, and German also are taught as foreign languages beginning in Grade 9.

Mathematics Curriculum in Primary and Lower Secondary Grades

Currently in Morocco, a new primary school curriculum is under development, which is aligned with the vision of the National Reform for Education and Training and in compliance with the National Education Emergency Support Program. The curriculum also reflects the newly adopted competency-based approach and its offshoot, the pedagogy of integration, which emphasizes the need to train students to face the challenges of globalization and technological development.[10] Accordingly, as was the case with the 2002 mathematics and science curriculum, the new curriculum draws upon the tenets of the competency- and value-based approaches, as well as the innovative active learning-oriented pedagogical model.[11]

The mathematics curriculum content for both grades reflects continuity between primary and secondary education, enabling students to strengthen previously learned concepts and skills while developing others. Generally, the curriculum enables students to strengthen their mathematical reasoning. Specifically, the fourth grade mathematics curriculum aims to enable students to do the following:

- Enjoy learning through practical activities;
- Gain confidence and competence in using numbers and number systems;
- Develop problem-solving abilities;
- Explore shape and space within a range of meaningful contexts;
- Develop measuring skills in a range of contexts; and
- Develop insights into the importance of mathematics in a growing number of occupations and in daily life.

The fourth grade syllabus for mathematics is organized around the following areas: [12]

- Place value—Numbers up to 999,999 (addition, subtraction, multiplication, division, and using written and mental calculation strategies).
- Measurement—Length, weight, time, capacity, and volume.
- Geometry—Basic geometric patterns, such as rectangular and square symmetry, rotational symmetry, and translations.

The eighth grade mathematics curriculum aims to enable learners to do the following:

- Acquire and apply knowledge and skills pertaining to number, measurement, space, and statistics necessary for use in everyday mathematical situations;
- Acquire mathematical knowledge and skills necessary for further mathematics studies;
- Develop the ability to make logical deductions and inductions through problem solving;
- Acquire oral and written language skills to clearly communicate mathematical ideas and arguments;
- Develop a positive attitude toward, confidence in, and enjoyment of mathematics;
- Develop the ability to appropriately monitor and evaluate one's own progress; and
- Develop the skills necessary to plan and carry out a project.

The content of the mathematics syllabus for the eighth grade includes the following components: [13]

- Number—Numerical operations on rational numbers, powers of real numbers, and solving equations and formulas for a given variable.
- Statistics.
- Geometry—Axial symmetry, the Pythagorean theorem, the cosine of an angle, vector equality, and vector addition.

Science Curriculum in Primary and Lower Secondary Grades

As stated above, Morocco's 2002 curriculum draws upon the tenets of the competency- and value-based approaches, as well as the innovative active learning-oriented pedagogical model. The science curriculum content for both fourth and eighth grades reflects continuity between primary and secondary education, enabling students to strengthen previously learned concepts and skills while developing others.

The goals of the fourth grade science curriculum are as follows: [14]

- Build upon interest in and stimulate curiosity about our environment through high-quality science learning experiences;
- Gain deeper personal insights and, by implication, gain aesthetic appreciation of the natural world;
- Develop scientific inquiry skills, attitudes, and values;
- Develop the ability to use scientific knowledge and methods in making personal decisions; and
- Maximize understanding of the influence of science and technology on our environment and our lives.

The syllabus for fourth grade science includes the following topics:

- Types of gases and common properties of gases;
- Nutrition, balanced meals, and principles of digestion;
- Locomotion, especially adaptations of animals living in water;
- Measuring matter;
- Physical and chemical changes;
- The life cycle, with insects and plants as models;
- Classification of animals;
- Classification of flowering plant families;
- Water and the environment, water use and conservation, pollution, and organisms in nature; and
- Electricity and how electric circuits work.

The eighth grade science curriculum is designed to enable students to gain awareness and understanding of the skills needed in science. The distinguishing feature of the syllabus for this grade is that it focuses equally on the acquisition of scientific knowledge and thinking processes. It is organized around the following areas: [15]

- The theory of plate tectonics, evidence supporting the movement of continents, geological phenomena, earthquakes, volcanoes, tectonic processes resulting in the formation of rocks and mountains, and the Earth system;
- Animal reproduction, fertilization, continual development, and the concept of developmental stages;
- Plant reproduction and its processes;
- Reproductive systems and their functions, pregnancy, delivery, breast feeding, and birth control;
- Heredity, hereditary characteristics and diseases, and the role of reproductive cells in the transmission of hereditary characteristics;
- The genetic ill-effects of intermarriage among blood relatives; and
- Cloning.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

In Morocco, fourth grade mathematics is taught two lessons per week, each lasting 2.5 hours. Of these five hours of instructional time, one hour is devoted to remedial work and one hour is devoted to assessment. Eighth grade mathematics is taught for four hours per week. Science is taught weekly in two 45-minute sessions for fourth grade. At the eighth grade, science it taught for 28 hours each semester, focusing on each content area for between two and eight hours.

Instructional Materials, Equipment, and Laboratories

Mathematics and science teachers across the country use textbooks approved by the Ministry of National Education, in compliance with book specifications issued by the ministry. Teachers can supplement the textbooks with materials designed by inspectors or supervisors to further address specific student needs.

Until 1999, textbooks had been designed by committees within the ministry. As of the 2012–13 school year, a new generation of primary school textbooks will be available following approval by a jury consisting of content area specialists appointed by the ministry.[16]

Science laboratories are not always available in primary schools. However, all lower secondary schools have their own science laboratories that accommodate requirements of the national curriculum. Greater efforts are being made to recruit more qualified laboratory technicians in order to ensure equipment maintenance and safety.

Use of Technology

Since 1999, the Ministry of Education has been implementing a policy promoting information and communication technology (ICT) in education, in accordance with Article 10 of the Charter of Education and Training.[17] In March 2005, the ministry launched the Generalization of Information Technologies and Communication in Education (GENIE) initiative to improve the quality of teaching and learning through the use of ICT in all public schools.[18] Through GENIE, all Moroccan schools are being equipped with computer laboratories supported by ADSL Internet access and are providing training for teachers, headmasters, advisors, and inspectors.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Teachers with specialties in mathematics and science are critical for improving student mathematical ability and self-confidence. However, primary school teachers, unlike their peers in lower secondary schools, are not required to specialize in mathematics and science.

Homework Policies

Educators in Morocco tend to continue to prioritize homework assignments. Homework builds responsibility, self-discipline, learner autonomy, and lifelong learning habits and provides reinforcement for learning outcomes. Homework assignments include practice tasks or activities, preview assignments, extension assignments, and creative activities.

Teachers and Teacher Education

Teacher Education Specific to Mathematics and Science

The Teacher Training Center for Primary School Teachers (*Centre de Formation des Instituteurs*) and the Regional Pedagogical Center (*Centre Pédagogique Régionale*) for lower secondary school teachers provide full-time courses and a practicum leading to a professional graduate certificate in education. In order to be admitted to either teacher college, applicants must hold a two-year General University Studies Diploma (*Diplôme d'Etudes Universitaires Générales*), pass an entrance examination, and participate in a background interview. Teacher education at the colleges consists of a practice-based, one-year course for teachers, which includes a practicum and supervised class observations intended to provide hands-on experience in teaching.

Teacher education is generally divided into two major areas:

- Foundational knowledge about specific issues related to the philosophy of education, education psychology, and the sociology of education; and
- Methodologies for teaching different content areas.

Upon the successful completion of the training course, teacher trainees are appointed to primary or lower secondary schools.

Requirements for Ongoing Professional Development

The National Charter for Education and Training prioritizes professional development of teachers and school administrators.[19] Pedagogical inspectors play an important role in the education system in Morocco. They design teacher professional development programs, colloquia, and seminars and supervise teachers, among other endeavors, to further improve teaching and learning within the 16 Regional Academies for Education and Training across the country.

Monitoring Student Progress in Mathematics and Science

The Ministry of National Education in Morocco has implemented policies that require students to pass exit examinations at each level of education in order to obtain a leaving certificate and, by implication, continue to the next level. However, within primary school, students are automatically promoted from one grade to the next. Correspondingly, dropout rates have declined during the last ten years, particularly for primary school students.

At each educational cycle, the following exit examinations are administered:

- Primary School Exit Examination—This examination is given across the 16 regions, and is developed by commissions of experienced teachers and inspectors from the *Délégations* and the Academies for Education and Training, respectively. Students are required to pass this examination to be eligible for admission to lower secondary school.

- Lower secondary School Exit Examination—This examination also is given across the 16 regions, and also is developed by commissions of experienced teachers and inspectors from the *Délégations* and the Academies for Education and Training, respectively. Successful students are awarded a leaving certificate and are eligible for enrollment in upper secondary schools.
- The Baccalaureate Examination—This is a national achievement examination developed at the National Center for Examinations. The exam takes 3 or 4 days to complete and covers the content and objectives outlined in the syllabi for upper secondary education. The content included in the Baccalaureate depends on the specific coursework taken by the student. Some subjects are tested either through school assessment at the end of the first or second year of Baccalaureate-track education or through the regional *Academie*, an examination given in the second semester of the first year of Baccalaureate-track education. Students who achieve an overall average of 10 or better on a 20-point scale are awarded the Baccalaureate Diploma. The National Charter for Education and Training stipulates that all students who pass the Baccalaureate examination are eligible (in the year in which they pass the examination) for tuition-free studies at one of the public universities across the country.

Formative assessment is an important source of feedback for teachers and is geared toward helping them to gauge the effectiveness of their teaching strategies in relation to the curriculum as well as to orient teaching style to student learning style. Teachers use formative assessment aligned with ministerial circulars and pedagogical guidelines as a source of information about student progress and ability.[20] Formative assessments are curriculum-based tests of student competencies, which provide opportunities for remediation.[21]

Teachers administer formative assessments at the end of the first semester and the end of the school year. These are school-based tests and are administered under standardized testing conditions. Their purpose is to determine how well students have achieved the overall syllabus objectives for the semester or year. Tests are broad in coverage and assess a representative sample of content from the syllabus covered during the semester or year. Teachers also administer short quizzes at different stages of instruction.

The 1999 Charter for Education and Training stipulated that Morocco's assessment and certification system should be overhauled. In response, the National Center for Evaluation and Examinations has led significant reform of the assessment and certification system. In an effort to ensure uniformity and standardization in the evaluation process, the center developed frameworks and guides for the design, administration, and scoring of exam papers. Moreover, in collaboration with the Higher Council for Education, the center launched the National Program for the Evaluation of Acquired Learning Outcomes (*Programme National d'Evaluation des Acquis*, or PNEA) to implement a periodic assessment of student learning. The PNEA nationwide system of assessment makes it possible to gauge whether or not learning outcomes have been met, and to define a benchmark against which to systematically evaluate the quality of education being provided. The executive summary of PNEA 2008 includes a series of recommendations to improve the teaching and learning of languages, mathematics, and science.[22]

An in-depth diagnosis of the school exams and certification system is underway within the National Center for Evaluation and Examinations with the aim of redefining the system within a national policy framework for evaluating learning outcomes. The National Education Emergency Support Program is, in part, the outcome of a variety of studies and assessments, and aims to further build the credibility of the assessment and certification system.

Impact and Use of TIMSS

The reliable, valid, and detailed data that TIMSS provides about Moroccan student achievement in mathematics and science has been beneficial to education reform in Morocco. Equally important are the TIMSS data about the educational environment within which students learn these two subjects at the primary and lower secondary levels. Through the international perspective provided by TIMSS, Moroccan educators have gained deeper insights into ways to further improve mathematics and science teaching.

The National Center for Evaluation and Examinations, in collaboration with the Regional Academies of Education and Training, organized 16 nationwide seminars geared toward implementing the provisions of the National Education Emergency Support Program regarding student assessment. These seminars were an opportunity to disseminate data about Moroccan student achievement in mathematics and science (as well as reading) and identify the areas and skills needing further attention. Educators, parents, and other stakeholders were called upon to develop improvement plans to help students enhance their competency in mathematics and science.

In light of Morocco's TIMSS results, the Ministry of National Education has launched the Evaluation of Prerequisites program (*L'Evaluation des Prérequis*) designed to nurture a culture of assessment in mathematics and science, and particularly to diagnose key competencies (and resources) students should master within the new science and mathematics curriculum. This program, administered nationwide at the very beginning of each school year, enables teachers to identify students' areas of strength or areas needing improvement during instruction and according to each students' individual learning pace.[23] Within the framework of the assessment program, diagnostic tests are administered and scored at the very beginning of the school year. Students with similar learning difficulties are grouped and specific remedial work programs are designed and implemented for these student groups. One of the major benefits of this program is that when teachers cannot easily resolve students' difficulties on their own, headmasters, inspectors, pedagogical advisors, and school management councils are all called upon to develop a context-specific improvement plan to provide more extra-curricular student support.

Similar to the Evaluation of Prerequisites program, National Program for the Evaluation of Acquired Learning Outcomes (PNEA) ensures efficient and objective evaluation of student achievement. PNEA was designed to assess and monitor student competencies with a broader perspective on matters of curriculum, training, and research from international assessment results.[24]

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The Netherlands

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Introduction

Overview of the Education System

Dutch schools traditionally have significant autonomy. The Dutch education system is based on the principle of freedom of education, guaranteed by Article 23 of the Constitution.[1] Each resident of the Netherlands has the right to establish a school, determine the principles on which the school is based, and organize instruction in that school. Public and private schools (or school boards) may autonomously decide how and, to a large extent, when to teach the core objectives of the Dutch curriculum based on their religious, philosophical, or pedagogical views and principles.

The Minister of Education, Culture, and Science is primarily responsible for the structure of the education system, school funding, school inspection, the quality of national examinations, and student support.[2] The administration and management of schools is decentralized and is carried out by individual school boards. Specifically, these boards are responsible for the implementation of the curriculum, personnel policy, student admission, and financial policy. A board can be responsible for one school or for a number of schools. The board for public schools consists of representatives of the municipality. The board for private schools often is formed by an association or foundation. However, both school types are funded by the central government and, to some extent, by the municipalities.

Two-thirds of schools at the primary level are privately run. The majority of private schools are Roman Catholic or Protestant, but there also are other religious schools and schools based on philosophical principles. The pedagogical approach of a small number of schools is based on the ideas of educational reformers such as Maria Montessori, Helen Parkhurst, Peter Petersen, Célestin Freinet, and Rudolf Steiner.

The Dutch Inspectorate for Education makes visits at least once every four years to ascertain whether schools, both public and private, provide the expected quality of education.[3] Schools not meeting quality standards are visited more frequently.[4] The inspectorate can apply sanctions to very low performing schools, however, the final decision about whether or not a school should be closed is made by the Minister of Education, Culture, and Science. The findings from school inspection visits are reported back to the individual schools, the government, and the public.

In the Netherlands, the same school offers preprimary and primary education. Most children begin preprimary education at age four, though the first year is not compulsory. Preprimary education (Kindergarten) lasts two years and has both a social and an academic function, although the basics of reading, writing, and mathematics usually are taught beginning in the first year of primary education. Together, preprimary and primary education consists of eight grades, so the majority of children are twelve years old when they begin secondary education.

Compulsory education begins the first day after the month of child's fifth birthday and either concludes at the end of the school year of the student's sixteenth birthday when he or she obtains an upper secondary education (ISCED level 3) diploma, or concludes at the end of the school year of the student's eighteenth birthday.

Most secondary schools in the Netherlands offer more than one track. After two years of basic education in secondary school (Grades 7 and 8), students enroll in one of the following three tracks:

- Pre-vocational Secondary Education—This track lasts two additional years and offers four learning pathways: basic vocational; middle management vocational; combined vocational and theoretical; and theoretical. After completing pre-vocational secondary education, students may continue on to one of two secondary programs: vocational secondary education, or senior general secondary education.
- Senior General Secondary Education—This track lasts three additional years and offers general secondary education in four different programs: science and technology, science and health, culture and society, and economics and society. Upon completion of a program, students can continue on to an additional, pre-university secondary education program or to higher education in a higher vocational education program.
- Pre-university Secondary Education—This track lasts four additional years and offers the same four programs as senior general secondary

education. Upon completion, students may continue to higher education in a three-year bachelor's degree program.

Tertiary, or higher education, is divided into two programs: higher vocational education programs, and bachelor's degree programs. Higher vocational education programs lead to a four-year bachelor's degree. Bachelor's degree programs lead to a three-year degree, after which a master's degree can be earned in an additional one to three years.

The *Platform Bèta Techniek* is an important initiative that encourages students to pursue a mathematics- or science-related career, and involves schools, universities, businesses, ministries, municipalities, and regions.[5] Commissioned by the government in 2004, the initiative's main goal has been to increase the number of students who participate and finish higher (vocational) education in science or technology. The success of the initiative has resulted in a continuation and extension of the program. From 2011 until 2016, the program will focus on firmly embedding science and technology into teacher education, encouraging 55 percent of students in senior general secondary education and pre-university secondary education and 40 percent of students in pre-vocational secondary education to choose a science track, and increasing the quality of teaching in primary and secondary education.[6]

An example of a project of the *Platform Bèta Techniek* is VTB-Pro, a program targeting primary school teachers. In this program, additional training in science and technology in an attractive, real-life context is provided to a total of 10,000 primary school teachers and students at teacher training colleges. The program's ultimate goal is to influence teachers' attitudes towards science and technology as well as to make science and technology education more attractive to primary school students and increase students', especially girls', self-confidence in these subjects.

Languages of Instruction

Dutch is the first official language in the Netherlands. Frisian, the second official language, is spoken by more than 350,000 people in the northern province of Friesland.[7] Dutch is the first language of instruction in schools, although Frisian or a regional dialect may be taught alongside Dutch. A minority of secondary schools offer Frisian as an optional final examination subject.

Approximately 11 percent of the general population and 15 percent of students in secondary education belong to a non-western ethnic minority.[8] By definition, a student belongs to a non-western ethnic minority if one parent was born in Turkey, Africa, Latin America, or Asia (excluding Indonesia and Japan). These students, compared with native students and nonnative students from western countries, are overrepresented in the lowest track of secondary education (pre-vocational secondary education).[9]

Mathematics Curriculum in Primary and Lower Secondary Grades

The mathematics curriculum for primary school is described in eleven core objectives. During primary school, students should become familiar with mathematical basics offered in a recognizable and meaningful context. Primary school students will gradually acquire familiarity with numbers, measurements, and two- and three-dimensional geometric shapes and solids, as well as the relationships and calculations that apply to them. Students will learn to use mathematical language while gaining mathematical literacy and calculation skills.[10] By the end of primary school, students should be able to do the following:

- Use mathematical language;
- Solve practical and formal mathematics problems and clearly demonstrate the solution process;
- Identify different approaches for solving mathematics problems and learn to assess the reasonableness of solutions;
- Understand the general structure and interrelationship of quantities, whole numbers, decimal numbers, percentages, and proportions, and use these to do arithmetic in practical situations;
- Quickly carry out basic arithmetic calculations mentally, using whole numbers through 100, and learn the multiplication tables;
- Count and calculate by estimation;
- Add, subtract, multiply, and divide by taking advantage of number properties;
- Add, subtract, multiply, and divide on paper;
- Use a calculator with insight;
- Solve simple geometrical problems; and
- Measure and calculate using units of time, money, length, area, volume, weight, speed, and temperature.

For the first two years of secondary school, the mathematics curriculum is described in nine core objectives.[11] By the end of these two years (the end of Grade 8) of mathematics education, students should be able to do the following:

- Use appropriate mathematical language to organize mathematical thinking, explain things to others, and understand explanations in the context of mathematics;
- Learn, individually and in collaboration with others, to recognize and use mathematics to solve problems in practical situations;
- Establish a mathematical argument and distinguish it from opinions and allegations, thereby learning to give and receive mathematical criticism with respect for other ways of thinking;
- Recognize the structure and coherence of the systems of positive and negative numbers, decimal numbers, fractions, percentages, and proportions, and thereby learn to work with these systems meaningfully in practical situations;
- Make exact calculations, provide estimates, and demonstrate an understanding of accuracy, order of magnitude, and margin of error appropriate in a given situation;
- Make measurements, recognize the structure and coherence of the metric system, and calculate with measurements in common applications;
- Use informal notations, schematic representations, tables, diagrams, and formulas to understand connections between quantities and variables;
- Work with two- and three-dimensional shapes and solids, make and interpret representations of these objects, and calculate and reason using their properties; and
- Learn to systematically describe, order, and visualize data and to critically judge data, representations, and conclusions.

Science Curriculum in Primary and Lower Secondary Grades

In primary education, science is taught within the Personal and World Orientation content area. The curriculum in this area is organized to teach students to "orientate on themselves, on how people relate to each other, how they solve problems, and how they give meaning to their existence."[12] The educational content of personal and world orientation is presented coherently, and content from other learning areas is applied as much as possible. The seven core objectives for nature and technology, and the science subcategory of Personal and World Orientation, lead students to be able to do the following:

- Distinguish, name, and describe the roles and functions of common plants and animals;
- Describe the structures of plants, animals, and humans and the form and function of their parts;
- Research material and physical phenomena, including light, sound, electricity, power, magnetism, and temperature;
- Describe weather and climate in terms of temperature, precipitation, and wind;
- Find connections between form, material composition, and function of common products;
- Design, implement, and evaluate solutions to technical problems; and
- Describe the positions and motions of the Earth-sun system that cause the seasons as well as night and day.

In secondary school, the first year of science is taught as part of the core objectives of the Man and Nature content area and comprises eight objectives.[13] By the end of the first year (the end of Grade 7) of secondary school science, students should be able to do the following:

- Transform questions arising from topics pertaining to the sciences, technology, and human health and welfare into research questions; and carry out an investigation on a scientific topic, and present the results;
- Acquire knowledge about and insight into key concepts of living and nonliving things and connect these key concepts with situations from everyday life;
- Describe how people, animals, and plants are related to each other and the environment, and how technological and scientific applications can have permanent positive or negative influences on these living systems;
- Acquire knowledge about and insight into the nature of living and nonliving things, as well as their relation to the environment, through experimentation;

- Work with theories and models by investigating chemistry and physical science phenomena, such as electricity, sound, light, movement, energy, and matter;
- Acquire knowledge about technical products and systems through investigation, estimate the value of this knowledge, and design and construct a technical product;
- Understand the essential structures and functions of human body systems, establish connections between these systems and the promotion of physical and psychological health, and take responsibility for one's own health; and
- Care for oneself, others, and one's environment, and positively influence one's own safety and the safety of others.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Materials, Equipment, and Laboratories

Schools are free to choose the instructional materials they use with no government prescription. Several varieties of commercially developed instructional materials and teaching methods are available for schools, though some schools develop their own materials. The Dutch Institute for Curriculum Development advises schools about the appropriateness of available instructional materials and teaching methods for the Dutch curriculum. Primary schools usually do not have science labs, but most secondary schools do.

Use of Technology

Since 1997, the implementation of information and communication technology (ICT) in education has been an important component of the governments' educational policy.[14] Almost every school uses computers for educational purposes. There is approximately one computer available for every five students in the Netherlands, and virtually all computers have Internet access.[15] Sixty to ninety percent of primary and secondary teachers use computers in their teaching.[16] The use of smartboards also is widespread in both primary (on average, one in every two classrooms) and secondary schools (on average, one in every six classrooms).

Knowledge Net (*Kennisnet*) is the main public support organization for educational ICT use in primary, secondary, and adult education in the

Netherlands and is supported by the government. The mission of Knowledge Net is "to support and inspire educational organizations with independent expertise and services regarding the effective use of ICT." [17]

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

In primary education, mathematics and science are usually not taught by specialized subject teachers. A primary school teacher is trained to teach all subjects (except physical education) and all grades of preprimary and primary education. In secondary education, all teachers are subject-specific teachers. As a consequence, different types of colleges provide education for primary and secondary education teachers.

Homework Policies

Schools can decide homework policies individually. Although students in primary education are not expected to do homework, some primary schools give students homework to prepare them for homework in secondary education. In secondary education, homework is very common, but the assignments vary significantly among schools and teachers.

Teachers and Teacher Education

Candidates must earn a diploma from one of the Netherlands' primary school teacher education colleges to qualify to work as a primary school teacher.[18] Primary school teacher education usually takes four years to complete. Primary school teacher training is provided at the higher vocational education programs level. Students with a diploma at the highest level from pre-university secondary education, senior general secondary education, or vocational secondary education also can apply to these programs. Each primary school teacher is allowed to teach all grades and all subjects in primary education, with the exception of physical education.

Since 2006, students starting at a teacher education college have been tested on their Dutch language and mathematics skills in order to guarantee standards of competence.[19] If students fail the test, they have one school year to improve their language and mathematics skills. If such students are not capable of passing the test by the end of the year, they cannot continue to the next year.

From the first year of teacher education, students receive practical work experience through regular teaching practice in primary schools. About a quarter of teacher training is devoted to instructional practice. Halfway through teacher education, students can choose to specialize in lower primary (Kindergarten to Grade 2) or upper primary (Grades 3–6).

Secondary school teachers are subject teachers.[20] Most of these teachers are trained in one subject as well as general teaching at teacher training colleges for secondary education. These teacher education colleges admit students with a diploma at the highest level from pre-university secondary education, senior general secondary education, or vocational secondary education. In the final year of their program, students receive practical work experience during a combined period of work and study at secondary schools. With a bachelor's diploma from a teacher training college, a teacher qualifies as a Grade 2 teacher and is allowed to teach the lower grades (Grades 7, 8, and 9) of senior general secondary education and pre-university secondary education and all grades of pre-vocational and vocational secondary education. Teachers qualified as "Grade 1 Teachers" often have a university degree (e.g., a master's degree in mathematics) with an additional master's degree in general teaching. A "Grade 1 Teacher" can teach all grades in all tracks in secondary education.

Requirements for Ongoing Professional Development

A variety of courses and other voluntary professional development activities are available for both primary and secondary school teachers. Teacher professional development courses are offered by teacher training colleges, universities or (commercial) institutes, as well as organizations offering educational advice and support. Furthermore, teachers can participate in subject-related workshops or conferences. Many general and subject-specific digital journals, magazines, and newsletters also are available for teachers.

Monitoring Student Progress in Mathematics and Science

In addition to autonomously deciding how and, to a large extent, when to teach the core objectives of the Dutch curriculum, schools may decide when to assess students. Schools often use "curriculum-embedded" tests that match the subject matter provided in the textbooks that are being used to teach various subjects.

During primary education, there are no national examinations. At the end of primary school, however, the vast majority of schools use multiple-choice tests developed by Cito (the National Institute for Educational Measurement). Cito tests measure academic skills in four areas: language, arithmetic and mathematics, study skills (e.g., using different sources of information, schedules, and tables), and world orientation (e.g., knowledge of history, science, and geography).[21] The results of these (or similar) tests, along with the recommendations from classroom teachers, are used to determine the most appropriate secondary school track for each student.

The end of primary school examination also is part of a student monitoring system called the Student Tracking System (*Leerling-en onderwijs volgsysteem*, or LOVS), which is used to assess the competence of students in Grades 1–8. LOVS allows teachers and schools to monitor and improve the development of individual students, as well as entire classes, throughout primary education and the first two years of secondary education. This system, developed by Cito, also is used by the Dutch education inspectorate to assess the quality of education in each school.

Secondary education concludes with national examinations in each subject during the last month (usually around May) of the final year of education (Grades 10, 11, or 12, depending on the track). The content of these examinations depends on the track and the program of the student. Cito also has developed a student monitoring system for the first three years of secondary education, called VAS, under which students are tested regularly. This system includes an instrument called Studeon that is used for measuring the social-emotional development and learning motivation of students.

Student grade promotion policies are determined by individual schools and are described in the School Guide. The Ministry of Education, Culture, and Science discourages retention, because it is assumed that retention will decrease student motivation and not necessarily address the student's learning difficulties.[22]

Impact and Use of TIMSS

After participating in both IEA's First and Second International Mathematics Studies and the First and Second International Science Studies, the Netherlands has participated in all TIMSS studies conducted to date: in 1995, Dutch students participated in Grades 3–4, Grades 7–8, and in the final year of secondary education; in 1999, students participated in Grade 8; in 2003, students participated in both Grades 4 and 8; and in 2007, students participated in Grade 4. The Netherlands also participated in TIMSS Advanced 2008 (Grade 12).

The Dutch government aims to be among the top five knowledge economies of the world. High quality education and well-educated students, especially in mathematics and science, are necessary to achieve this. Until 2003, the Netherlands performed very well in TIMSS, especially in mathematics (one of the top ten countries). However, the TIMSS 2007 results showed a slight but significant decline in mathematics performance at Grade 4, compared to TIMSS 1995. The results of PISA 2009 for secondary education were consistent with the TIMSS results in Grade 4. As a result, these results have supported governmental initiatives and projects to increase student performance in mathematics.[23]

A growing concern about Dutch children's mathematical proficiency also has led to a public debate in recent years about the way mathematics is taught in the Netherlands. There are two opposing camps: those who advocate teaching mathematics in the "traditional" manner, and those who support "realistic mathematics education." [24] The results from TIMSS 2007 have been used as arguments for both sides in the debate. However, in the last two decades, most primary schools have implemented mathematics methods based on realistic mathematics education.

At the primary school level, TIMSS results have not generated the same level of conversation among science educators.

Suggested Readings

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New Zealand

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Ministry of Education

Introduction

Overview of the Education System

New Zealand has a decentralized system, with each school having the authority for its day-to-day operations and financial management. Legal responsibility for governing schools is assigned to boards of trustees, comprised of elected parent and community volunteers, the school principal, a staff representative, and, in secondary schools only, a student representative. Boards of trustees must establish a charter for their school and work within the framework of guidelines, requirements, and funding arrangements set by the central government, in accordance with the National Education Guidelines and the Education Act 1989.[1]

Government agencies that play pivotal roles in establishing national policy and quality assurance across New Zealand's education system are the following: the Ministry of Education, the Tertiary Education Commission,[a] the Education Review Office, and the New Zealand Qualifications Authority.[b] Three of these bodies have responsibilities directly related to the curriculum: the Ministry of Education, the Education Review Office, and, to a lesser extent, the New Zealand Qualifications Authority.[2]

The Ministry of Education (the Ministry) is the government's lead agency for the education system, giving direction for other agencies and education providers. The Ministry has responsibility for developing national curriculum materials and providing operating guidelines for educational institutions. One of the main functions of the Ministry is to provide policy advice to the government and to oversee implementation of approved education policies. It also collects and processes education statistics and information, and monitors the education system's effectiveness. The Ministry allocates funds and resources to education institutions and professional development programs and it manages a large property portfolio.

a The Tertiary Education Commission is not discussed further because its role is outside the schooling sector.

b Three other bodies have major roles in education in New Zealand. Careers New Zealand *Rapuara* assists with the transition from education to work. It has a role to train career advisors. In addition, Education New Zealand is the Crown Agency responsible for New Zealand's international education promotion and representation worldwide. The New Zealand Teachers Council is the third body and is described later in this article in the section on teacher education.

The Education Review Office evaluates the quality of education provided within each early childhood center and school. Within each school, the evaluation indicators used during the review focus on all aspects of the school including student engagement and learning progress, staff and community engagement, leadership and governance, and statutory compliance. The reviewers look for evidence of a high quality self-review process that ensures the school community concentrates on improvement. However the overarching focus of a review is the effectiveness of the school's curriculum in promoting student learning.[3]

The New Zealand Qualifications Authority oversees and coordinates all national qualifications (e.g., secondary, academic, professional and trade qualifications, and certificates). Within the school system, the authority manages the assessment and reporting systems for New Zealand's national senior secondary school qualifications.

While the Ministry has the responsibility for developing national curriculum statements, individual schools and teachers decide how the curriculum is implemented, with oversight from boards of trustees. The Education Review Office monitors the implementation of the curriculum and publishes these findings.

Structure of the Education System

Exhibit 1 illustrates the structure of the early childhood and schooling sectors in New Zealand. Early childhood education in New Zealand is available from birth to age 6 and includes a wide range of early childhood services. Free early childhood education is currently available for up to 20 hours per week.[c, 4] While not compulsory, the majority of children attend teacher- or parent-led early education services before starting primary school.[d, 5]

Teacher-led services include kindergartens, education and care services, and home-based services. Parent-led services include *kōhanga reo*, playcenters, and playgroups. *Kōhanga reo*, meaning "language nest," is a family- and parent-led service designed to immerse children from birth until school age in Māori language, culture, and values. Playcenters are licensed parent-led services based on the philosophy of child-initiated play and parents as first educators. Playgroups are certificated parent-led services and are often less formal than

c In 2010, children (ages 0–5) were enrolled for 20.1 hours per week, on average, in early childhood education services.

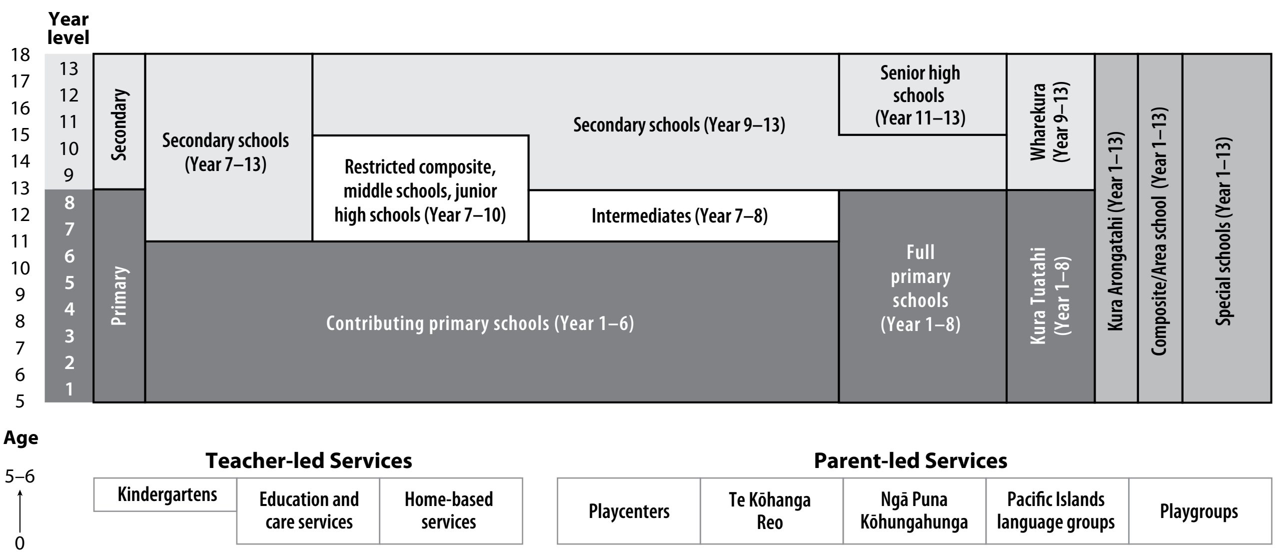
d Ninety-five percent of children who began school in the year prior to July 2010 participated in a licensed early childhood service immediately prior to beginning formal education.

the other services. A number of playgroups offer bilingual and total immersion programs in Māori and Pacific Islands languages.[e]

Early childhood services in New Zealand regard themselves as partners with families in the socialization, care, and education of children. The primary learning environment of early childhood education is a cultural and social setting rather than an academic setting. The principles of *Te Whāriki*, the Early Childhood Curriculum,[6] include the following:

- The empowerment of children to learn and grow;
- The development of children holistically (i.e., cognitively, socially, physically, emotionally, and spiritually);
- The importance of family and the community in children's development; and
- The importance of responsive and reciprocal relationships with people, places, and things in the development of children.

Exhibit 1: Structure of New Zealand's Early Childhood Education and Schooling Sectors[7]



Formal education is compulsory from ages 6 to 16. Although the compulsory starting age is six, the vast majority of children start school on or soon after their fifth birthday. While the majority of students complete their schooling within 13 years, a smaller number continue to study in the school

e In teacher-led services, 50% of adults educating and caring for children must be qualified, registered ECE teachers or, in the case of home-based education and care services, supported by coordinators who are registered ECE teachers. Parent-led services are licensed (or certificated) and involve parents and family/caregivers as the educators and caregivers of their children. Playcenters train parents as educators and supervisors (usually more than one per session) must have combined training over a specific level in order to run a session.

system for another one to two years.[f, 8] Each school has autonomy over how the curriculum is implemented and there is no tracking of students into academic or vocational streams or schools in New Zealand.

The schooling sector is loosely divided into two parts: primary education for students in Years 1–8, and secondary education for students in Years 9–13. However, the lines between primary and secondary are somewhat blurred within some schools that cater to both primary and secondary students; for example, area schools cater to students from Years 1–13. Note that the various types of primary and secondary schools shown in Exhibit 1 do not necessarily differ in the course of study offered but rather reflect the age range of children accepted (e.g., a full primary school covers Years 1–8 while a contributing primary school only covers up to Year 6).

Wherever possible, students with special education needs are catered to in their local school. Children and young people attending their local school who are assessed as having very high, high, or moderate support needs, are provided with additional support. Special education schools are provided for students who are unable to be accommodated within the mainstream schooling system.[9]

In primary schools, more emphasis is placed on reading, writing, and mathematics than science. Specifically, the main area of focus is on early foundations with an emphasis on literacy and numeracy, in particular for Māori, Pasifika, and students with special education needs.[10] Schools are instructed through the National Administration Guidelines to give priority to student achievement in literacy and numeracy especially in Years 1–8.[11]

Languages of Instruction

New Zealand has three official languages: Māori (the indigenous language), English (by virtue of its widespread use), and New Zealand Sign Language.[g] Māori, a *taonga* (treasure) recognized under the Treaty of Waitangi[h] and an official language since 1987, is a Malayo-Polynesian language closely related to the languages spoken in Tahiti, Hawaii, Rarotonga, and French Polynesia.[12] New Zealand Sign Language became the country's third official language in 2006. Other languages commonly spoken in New Zealand include Samoan, Tongan, Cantonese, Mandarin, and Hindi.[13, 14]

While most teaching and learning in New Zealand schools is in English, an important feature of the education system is Māori language education,

f Students in the system for more than 13 years will be repeating a year level at some stage of their education.

g Only Māori and New Zealand Sign Language have been given official status under acts of Parliament; this is not the case for English.

h The Treaty of Waitangi is New Zealand's founding document. It takes its name from the place in New Zealand where it was first signed, on February 6, 1840. The Treaty is an agreement, in Māori and English, made between the British Crown and about 540 tribal chiefs.

with students participating in Māori language classes in English-medium or Māori-medium schools.[15] Just under 4 percent of students were enrolled in bilingual or full immersion Māori-medium instruction in 2010.[i] For the majority of students learning in Māori-medium settings, Māori is their second language while English is their first. In 2010, less than 1 percent of primary and secondary students received some instruction in a Pacific Islands language, most often Samoan.[j, 16]

The New Zealand population is becoming increasingly ethnically diverse.[k, 17] The Ministry provides additional funding for schools to meet the needs of students from non-English-speaking backgrounds who are learning English as a second language. Most schools include students from non-English-speaking backgrounds in general classes and make arrangements, such as a teacher aide or individual lessons with a specialist teacher, for students needing additional help. In some schools, however, entire classes of students have English-language learning needs.

The New Zealand Curriculum in Primary and Lower Secondary Schools

The national curriculum guides teaching and learning in New Zealand. It is comprised of two documents: one for English-medium education, *The New Zealand Curriculum*, and one for Māori-medium education, *Te Marautanga o Aotearoa*. The English-medium document was introduced in late 2007 with full implementation expected in 2010. The Māori-medium document was introduced a year later, in late 2008, with full implementation expected in 2011.[l] The two documents have been developed independently and are not translations of each other. They both have the same goals—an "emphasis on foundation learning and academic success for all students and the competencies needed for study, work, and lifelong learning." [18] While the aims and objectives are not designed to be parallel, the two documents have many similarities due to similar learning goals for the whole of schooling and the understanding of learning progressions.

i Note that this 3.6% comprises 1.5% (of all New Zealand students) in full immersion programs (more than 80% instruction in Māori), 1.2% funded bilingual (31% to 80% instruction in Māori) and 0.8% with only 12% to 30% instruction in Māori. To be funded as Māori-medium, schools need to offer at least 30% of teaching in Māori.

j That is, 0.2% of New Zealand students received some instruction in a Pacific Islands language.

k The majority of New Zealanders identified themselves in the 2006 census as European (68%), with the second largest ethnic group being Māori (15%). Both Asian (9%) and Pacific peoples (7%) are increasing as a proportion of the New Zealand population. A small percentage of people identified themselves as Middle Eastern, Latin American, or African (1%). Although not an ethnic identity per se, approximately 1 in every 10 people identified themselves specifically as "New Zealanders" (11%). Note that percentages do not add to 100 because 10% of people identified with more than one of these groupings.

l Prior to 2007, the national curriculum comprised a framework and separate documents for each learning area. This new curriculum brings together all the learning areas into one document (that is one document for each of Māori- and English-medium schooling).

The English-medium document covers eight learning areas, two of which are Mathematics and Statistics and Science.[19] Similarly, the Māori-medium document covers nine learning areas, two of which are Mathematics (which includes statistics) and Science.[20] The learning areas differ only with respect to language: the English-medium document has two language learning areas, while the Māori-medium document has three.[m] Within each learning area, for both documents, there are eight curriculum levels designed to cover the 13 years of schooling. The alignment of curriculum levels with Year levels is flexible with each curriculum level in primary schooling, equating to approximately two or three years of schooling. Across secondary schooling, curriculum levels are approximately equivalent to one year of schooling. Teachers are expected to tailor lessons to meet students' individual needs. Thus, students in the same year level may be working at different curriculum levels as appropriate to their abilities and pace of progression.[n]

Within the mathematics learning area, the Māori-medium document has three strands: Number and Algebra, Measurement and Geometry, and Statistics. The English-medium document has these same three strands and a similar structure.

In addition to the national curriculum, there are National Standards for mathematics for students in Years 1–8. These standards detail expectations of skills and knowledge to be demonstrated by the end of each school year. National Standards in reading, writing, and mathematics were first implemented in 2010 for English-medium education[21] and in 2011 for Māori-medium education.[22] These dates coincide with the dates of full implementation of the respective curriculum documents.

Within the science learning area, the Māori-medium document has four strands: the Natural World, the Physical World, the Material World, and Philosophy and History of Science. The Natural World strand includes topics on the organism, the biological environment, Earth science, and astronomy. The English-medium document has these same natural world concepts under two strands: the Living World, and Planet Earth and Beyond. The Physical and Material World strands under both documents contain similar physics and chemistry topics, respectively. The Nature of Science strand in the English-medium document is similar to the Philosophy and History of Science strand in the Māori-medium document.

m Both curricula have *English* and *Learning Languages* as specific learning areas. The Māori-medium curriculum begins with the Māori language (*te reo Māori*) as its initial language learning area.

n For example, TIMSS 2007 showed that across Year 5 students some were working mostly at Level 2 of the curriculum, some were working mostly at Level 3, some were working across levels, and a small proportion were working at Levels 1 or 4. Note that teachers provided this data based on the majority of students in their class for mathematics and science strands separately.

Grades Assessed in TIMSS and Relation to the Curriculum

In New Zealand, the fourth year of formal schooling is Year 4. However, the average age of children in Year 4 is nine years old, which is lower than the required average age to participate in TIMSS (9.5 years). Therefore Year 5 students were assessed in TIMSS in New Zealand. Most students in Year 5 are expected to be working at early Level 3 of the curriculum. Students from Years 4, 6, and 7 may also be working at this level of the curriculum for some or all topics.

Similarly, the eighth year of formal schooling is Year 8. However, the average age of children in Year 8 is 13 years old, which is lower than the required average age to participate in TIMSS (13.5 years). Therefore Year 9 students were assessed in TIMSS in New Zealand. In Year 9 most students are expected to be working at early Level 5 of the curriculum. Students from Years 8 and 10 may also be working at this level of the curriculum for some or all topics.

Mathematics Curriculum in Primary and Lower Secondary Grades

New Zealand has only assessed students in English-medium settings in TIMSS, therefore the following summary details Level 3 of the English-medium document, with additional details provided by the National Standards.[o] The majority of students should have been introduced to or taught each of the following topics or skills by the end of Year 5:

- Number and Algebra—Use a range of additive and simple multiplicative strategies with whole numbers, fractions, decimals (simple), and percentages; know basic multiplication and division facts; know counting sequences for whole numbers; know how many ones, tens, hundreds, and thousands are in whole numbers; know fractions and percentages in everyday use; record and interpret additive and simple multiplicative strategies using words, diagrams, and symbols, with an understanding of equality; generalize the properties of addition and subtraction with whole numbers; and connect members of sequential patterns with their ordinal position and use tables, graphs, and diagrams to find relationships between successive elements of number and spatial patterns.
- Geometry and Measurement—Use linear scales and whole numbers of metric units for length, area, volume and capacity, weight (mass), angle, temperature, and time; find areas of rectangles and volumes of cuboids

o Experiences with TIMSS 2003, when Māori-medium schools were included, demonstrated that the mathematical and scientific vocabulary was too problematic at the Year 5 level. Given that many of these students were learning Māori as their second language, this difficulty with technical words is perhaps not surprising.

by applying multiplication; classify plane shapes and prisms by their spatial features; represent objects with drawings and models (simple nets and plans); use a coordinate system or the language of direction and distance to specify locations and describe paths; and describe transformations (reflection, rotation, translation, or enlargement) that have mapped one object onto another.

- Statistics—Gather, sort, and display multivariate categorical and whole-number data and simple time-series data to answer questions; identify patterns and trends in context, within, and between data sets; communicate findings using data displays; evaluate the effectiveness of different data displays; and investigate simple situations involving elements of chance by comparing experimental results with expectations from models of all outcomes, acknowledging that samples vary.

The following summary details Level 5 of the English-medium document.[p] Note that there are no National Standards for mathematics for Year 9 students. The majority of students should have been introduced to or taught each of the following topics or skills by the end of Year 9:

- Number and Algebra—Reason with linear proportions; use prime numbers, common factors and multiples, and powers (including square roots); understand operations on fractions, decimals, percentages, and integers; use rates and ratios; know commonly used fraction, decimal, and percentage conversions; know and apply standard form, significant figures, rounding, and decimal place value; form and solve linear equations; generalize the properties of operations with fractional numbers and integers; and relate tables, graphs, and equations to linear relationships found in number and spatial patterns.

- Geometry and Measurement—Select and use appropriate metric units for length, area, volume and capacity, weight (mass), temperature, angle, and time, with awareness that measurements are approximate; convert between metric units using decimals; deduce and use formulae to find perimeters and areas of polygons and volumes of prisms; find perimeters and areas of circles and composite shapes; deduce angle properties of intersecting and parallel lines and angle properties of polygons and apply these properties; create accurate nets for simple polyhedra and connect three-dimensional solids with different two-dimensional representations; construct and describe simple loci; interpret points and lines on coordinate planes, including scales and bearings on maps; define and use transformations and describe the invariant properties of figures

p At the Year 9 level, there are too few students in immersion mathematics and science courses to include in TIMSS.

and objects under these transformations; and apply trigonometric ratios and the Pythagorean theorem in two dimensions.

- Statistics—Determine appropriate variables and measures; consider sources of variation; gather and clean data; use multiple displays, and re-categorize data to find patterns, variations, relationships, and trends in multivariate data sets; compare sample distributions visually, using measures of center, spread, and proportion; present a report of findings; evaluate statistical investigations or probability activities undertaken by others, including data collection methods, choice of measures, and validity of findings; compare and describe the variation between theoretical and experimental distributions in situations involving elements of chance; and calculate probabilities, using fractions, percentages, and ratios.

Science Curriculum in Primary and Lower Secondary Grades

New Zealand has only included English-medium schools in TIMSS, so the following summary details Level 3 of the English-medium document.[q] The majority of students should have been introduced to or taught each of the following topics or skills by the end of Year 5:

- Nature of Science—Students will do the following: appreciate science as a way of explaining the world and that science knowledge changes over time; identify ways scientists collaborate and provide evidence supporting their ideas; build on prior experiences, working together to share and examine their own and others' knowledge; ask questions, find evidence, explore simple models, and carry out appropriate investigations to develop simple explanations; begin to use a range of scientific symbols, conventions, and vocabulary; engage with a range of science texts and begin to question the purposes for which these texts are constructed; use their growing science knowledge when considering issues of personal concern; and explore various aspects of an issue and make decisions about possible actions.

- Living World—Students will do the following: recognize that there are life processes common to all living things, and that these occur in different ways; explain how living things are suited to their particular habitats and how they respond to environmental changes, both natural and human-induced; begin to group plants, animals, and other living

q There are no National Standards for science. Also, experiences with TIMSS 2003, when Māori-medium schools were included, demonstrated that the mathematical and scientific vocabulary was too problematic at the Year 5 level. Given that many of these students were learning Māori as their second language, this difficulty with technical words is perhaps not surprising.

things into science-based classifications; and explore how groups of living things in the world have changed over long periods of time and appreciate that some living things in New Zealand are quite different from those in other areas of the world.

- Planet Earth and Beyond—Students will do the following: appreciate that water, air, rocks and soil, and life forms make up our planet, and recognize these as Earth's resources; investigate the water cycle and its effect on climate, landforms, and life; and investigate the components of the solar system, developing an appreciation of the distances between them.
- Physical World—Students will do the following: explore, describe, and represent patterns and trends for everyday examples of physical phenomena, such as movement, forces, electricity and magnetism, light, sound, waves, and heat. For example, identify and describe the effect of forces (contact and non-contact) on the motion of objects; and identify and describe everyday examples of sources of energy, forms of energy, and energy transformations.
- Material World—Students will do the following: group a range of materials in different ways, based on observations and measurements of characteristic chemical and physical properties; compare chemical and physical changes; and relate observed, characteristic chemical and physical properties of a range of different materials to technological uses and natural processes.

The following summary details Level 5 of the English-medium document.[r] The majority of students should have been introduced to or taught each of the following topics or skills by the end of Year 9:

- Nature of Science—Students will do the following: understand that scientists' investigations are informed by current scientific theories, and aim to collect evidence to be interpreted through processes of logical argument; develop and carry out more complex investigations, including using models; show an increasing awareness of the complexity of working scientifically, including recognition of multiple variables; begin to evaluate the suitability of the investigative methods chosen; use a wider range of science vocabulary, symbols, and conventions; apply their understandings of science to evaluate both popular and scientific texts (including visual and numerical literacy); and develop an understanding of socio-scientific issues by gathering relevant scientific

r There are no National Standards for science. Also, at the Year 9 level, there are too few students in immersion mathematics and science courses to include in TIMSS.

information in order to draw evidence-based conclusions and to take action where appropriate.

- Living World—Students will do the following: identify the key structural features and functions involved in the life processes of plants and animals; describe the organization of life at the cellular level; investigate the interdependence of living things (including humans) in an ecosystem; and describe the basic processes by which genetic information is passed from one generation to the next.
- Planet Earth and Beyond—Students will do the following: investigate the composition, structure, and features of the geosphere, hydrosphere, and atmosphere; investigate how heat from the Sun, the Earth, and human activities is distributed around Earth by the geosphere, hydrosphere, and atmosphere; and investigate conditions on the planets and their moons, and the factors affecting them.
- Physical World—Students will do the following: identify and describe the patterns associated with physical phenomena found in simple everyday situations involving movement, forces, electricity and magnetism, light, sound, waves, and heat (e.g., identify and describe energy changes and conservation of energy, simple electrical circuits, and the effect of contact and non-contact on the motion of objects); and explore a technological or biological application of physics.
- Material World—Students will do the following: investigate the chemical and physical properties of different groups of substances, (e.g., acids and bases, fuels, and metals); distinguish between pure substances and mixtures and between elements and compounds; describe the structure of atoms of different elements; distinguish between an element and a compound, and a pure substance and a mixture, at the particle level; and link the properties of different groups of substances to the way they are used in society or occur in nature.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Materials, Equipment, and Laboratories

There are no mandated materials for mathematics and science instruction in New Zealand; schools and teachers may choose which written materials they use in their classrooms. However, the Ministry of Education supplies some written resources free to schools. The *Building Science Concepts*[23] and the

Figure it Out[24] book series are key resources for primary schools in science and mathematics, respectively. As part of a cross-curricular approach, four of the *Figure it Out* books are based on mathematics in science contexts. Additionally, the *Connected*[25] series of student booklets are designed to engage students in mathematics, science, and technology. These booklets can also be used to teach reading skills because they contain different kinds of texts, including poetry. All of these resources suggest learning activities along with the materials needed to undertake the activities. Learning activities are designed so that they use materials that are readily available and familiar to students. Additional resources for schools and students include many textbooks and study guides written by private individuals.

Other resources include websites, videos, and CD-ROMs to support learning materials and demonstrate effective classroom practices. For example, the main Ministry website for supporting mathematics teaching and learning—*nzmaths* (http://www.nzmaths.co.nz/)—includes resources and a tool for planning lessons.[26] Similarly, *Science Online* (http://scienceonline.tki.org.nz/) is a key resource for New Zealand science teachers.[27]

In general, laboratories are only available in secondary schools. Individual schools make decisions regarding the purchase of instructional materials and equipment.

Use of Technology

The curriculum document for English-medium settings encourages schools to explore ways of using information and communication technology to support effective pedagogy.[28] Similarly, the document for Māori-medium settings supports the use of information and communication technology, stating that information technology is critical to the current generation and that it is an effective means of teaching and learning.[29]

Most New Zealand schools have computers available for use by students and teachers. In addition, a small minority of schools now require their students to provide their own laptops or tablets or to lease a laptop from the school for their schoolwork. A number of websites, including those sponsored by the Ministry of Education, contain resources suitable for student use. The Ministry runs a bilingual education portal called *Te Kete Ipurangi* (the Knowledge Basket).[30] This portal is designed to provide schools, teachers, and students with resources and information related to the curriculum, assessment, and school leadership. *Down the Back of the Chair*, the Ministry's online catalogue of teaching and learning resources for schools, is accessed via this portal.

Graphing calculators have become more widespread, particularly in senior secondary classes. Interactive whiteboards, also known as SMART™ Boards, are used in some schools, along with text messaging. Virtual learning environments are also used by teachers and their students, usually for homework purposes.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Most students have their first specialist teachers for mathematics and science beginning in Year 9, the first year of secondary education. However a few students have specialist teachers for these subjects in Years 7 and 8, and where there are teacher shortages, students may not have a mathematics or science specialist until Year 11, the first year of external examinations.

Homework Policies

There is no national policy to include homework as part of everyday student activities in New Zealand. However, an important principle of the curriculum is community engagement, to involve families and communities in the education of their young people. Schools, therefore, develop their own policies or guidelines on homework appropriate to their communities.

Teachers and Teacher Education

Teacher Education Specific to Mathematics and Science

New Zealanders can take a number of paths to become qualified teachers, through a range of teacher education providers. Universities, *wānanga* (Māori-based tertiary institutions), and accredited private training establishments offer initial teacher education programs for early childhood, primary, and secondary teaching. A number of teacher education providers offer degree programs for prospective teachers wishing to work in bilingual or Māori immersion settings.[31] Teacher trainees can either earn a bachelor's degree (in education or a specialist subject) followed by a Graduate Diploma of Teaching, or complete study that combines a bachelor's degree with teacher education. The New Zealand Teachers Council must approve all teacher education programs.[32]

All initial teacher education programs include a compulsory practicum lasting from 14 weeks for one-year post-graduate teacher education programs to about 26 weeks for three- or four-year degree programs. The practicum requires teachers to work under the supervision of experienced teachers in a range of schools. After graduating, beginning teachers are provisionally registered and must undergo further supervision for a minimum of two years.

Schools are required to provide high quality induction and mentoring programs for any provisionally registered teachers they employ to enable them to gain full registration.[33]

While there are no specific requirements for time spent on particular learning areas (subjects), initial teacher education programs must be designed to enable graduates to meet seven Graduating Teacher Standards, implemented in 2008. These standards state that graduating teachers should have the following capabilities: know what to teach; know about learners and how they learn; understand how contextual factors influence teaching and learning; use professional knowledge to plan for a safe, high quality teaching and learning environment; use evidence to promote learning; develop positive relationships with learners and the members of learning communities; and be committed members of the profession.[34]

Specialist secondary mathematics or science teachers are expected to have completed some tertiary level mathematics or science papers. Mathematics and the sciences are two of the five subject areas currently experiencing teacher shortages across the secondary education sector.[s, 35]

Requirements for Ongoing Professional Development

The New Zealand Teachers Council keeps a register of all qualified teachers and teacher registration is mandatory for all teachers employed in New Zealand schools. Upon registration, a teacher receives a practicing certificate, to be renewed every three years. Teachers must satisfy certain requirements, including satisfactory completion of work as a teacher endorsed by other staff within their school, to have their practicing certificate renewed. Specifically, teachers are expected to comply with the Registered Teacher Criteria.[36] One criterion requires teachers to demonstrate a commitment to ongoing professional learning and development of personal professional practice. A professional leader must testify that a teacher has undertaken satisfactory professional development at each certificate renewal (every three years). Schools are responsible for ensuring that teachers participate regularly in some form of professional development, the majority of which occurs in school contexts.

Monitoring Student Progress in Mathematics and Science

The Ministry of Education publishes the National Administration Guidelines (NAGs), which present statements of desirable principles of conduct for boards of trustees and school staff.[37] One of these guidelines states that schools should gather information that is sufficiently comprehensive to enable the

s English, Māori, and technology are the other three subjects experiencing shortages.

progress and achievement of students to be evaluated. Priority is placed on student achievement in literacy and numeracy from Years 1–8, but other aspects of the curriculum, including science, are expected to be covered.

There is no national testing in New Zealand until Year 11. Prior to this point, emphasis is placed on the professional judgment of teachers. Teachers are encouraged to use evidence from a range of assessment practices to monitor student progress and to diagnose students' learning needs. New Zealand teachers usually develop their own assessments to meet the needs of their students. While teachers have the freedom to write their own test items, there are many sources of items and tests they can use to compile their assessments. Three main standardized test sources, including either intact tests or single items, are available to schools: Assessment Resource Banks, Assessment Tools for Teaching and Learning, and Progressive Achievement Tests. In addition, exemplars are provided for the curriculum and the National Standards to illustrate students' expected outcomes. These pre-prepared tasks and tests use a variety of formats, including multiple-choice, and written and practical open-ended tasks.

The Assessment Resource Banks, developed by the New Zealand Council for Educational Research (NZCER), provide items in mathematics and science from which teachers can choose what to assess, for what purpose, and when.[38] Also produced by NZCER are two tests for use with students: *Progressive Achievement Tests* (mathematics)[39] and *Science: Thinking with Evidence*.[40] The science tests are designed to assess how well students use evidence to consider scientific contexts and issues. The science tests also allow teachers to identify specific aspects of students' thinking in the context of science, but do not attempt to measure overall science achievement. Diagnostic information is available for each of these assessment resources to assist teachers in making decisions about student learning needs.

The Assessment Tools for Teaching and Learning is an educational resource for assessing literacy and numeracy at Years 4–12.[41] Teachers can use this resource to create 40-minute paper-and-pencil tests designed for their students' learning needs. Once tests are scored, this tool generates interactive graphic reports allowing teachers to analyze student achievement against curriculum levels, curriculum objectives, and population norms.

Schools should use achievement information gathered through assessment when performing their required self-review of policies, plans, and programs. Schools are required to report individual achievement to each student and their parents as well as the achievement of particular student groups and students overall to the school's community. Reports on individual students must include their progress and achievement in relation to National Standards, must be presented in writing using plain language, and must be produced at least twice a year.[t, 42]

A major underlying premise of New Zealand's education system is that teachers and schools should meet the educational needs of individual students.[43] Students are promoted socially through the year levels. At the primary level, the use of classes with students from multiple year levels[u] (composite classes) is widespread. As a result of both social promotion and composite classes, there is often a wide range of abilities in each class. The New Zealand curriculum recognizes that students are likely to progress at different rates through each learning area, so teachers are expected to adapt their teaching to student needs.[44] Assessment is used in this context for formative purposes—to diagnose students' learning needs and to help improve teaching and learning.[45]

Students usually first experience entry restrictions to secondary school courses when they begin taking papers for qualifications. The National Certificates of Educational Achievement (NCEA) are the main national qualifications for secondary students. NCEA is awarded at three levels, known as Level 1, 2, and 3. Students usually begin studying for their Level 1 NCEA in Year 11 and continue through Years 12 and 13. The flexible design of these qualifications enables students to take any combination of courses across levels, depending on their abilities and previous attainments. For example, a Year 13 student could be taking Level 3 arts courses, while also taking Level 1 or 2 language courses. In each area of learning, different aspects of skills, knowledge, and understanding can be assessed separately, with assessments designed to suit the skill or knowledge being assessed.[46] A variety of assessment tools, including presentations, assignments, practical tests, and examinations are used. Schools also can offer a wide range of specialized National Certificates that provide either a starting point for further study or simply evidence of a broad general education. These include, for example, the National Certificate of Tourism, National Certificate in Computing, and National Certificate of Motor Engineering.

Impact and Use of TIMSS

Much of the focus on TIMSS results has been on international league tables and where New Zealand ranks in the world in terms of achievement. The

t The requirement to report against National Standards is only for reading, writing, and mathematics.

u There are exceptions to social promotion only in very special circumstances. Students will only be held back or promoted beyond their expected year level on recommendation of the school and on agreement with the parents.

wealth of contextual data collected in TIMSS, while making much less of an impact, has also been used to inform the New Zealand mathematics and science education communities.

New Zealand first participated in TIMSS 1995.[v] The release of the middle primary results highlighted areas of concern in mathematics and science education in New Zealand. The publication of these findings coincided with the implementation of a new curriculum. Difficulties that teachers reported with implementing the curriculum, combined with the TIMSS results, were the impetus for the establishment of the Mathematics and Science Taskforce in August 1997.[47] The Taskforce's recommendations led to a number of initiatives, such as developing mathematics and science resources for students and teachers, particularly in primary schools, research seminars to identify key issues in science and mathematics education, assessment tools for mathematics, and professional development programs focused on numeracy.

Since 1995, TIMSS has become an important part of monitoring and research within the New Zealand education system. New Zealand has participated in all cycles of TIMSS with the exception of the eighth grade component of TIMSS 2007 (omitted due to funding and operational constraints). In particular, TIMSS and PIRLS are used as indicators of current and past achievement and to set aspirational goals for future achievement. In the most recent Ministry of Education's *Statement of Intent 2011/12–2016/17*, which identifies the strategic direction for the agency, the second priority is as follows: "Every child achieves literacy and numeracy levels that enable their success," particularly students in Years 1 to 8. TIMSS will be one of the measures used to determine progress towards this outcome.[48] The international studies also enable the examination of equity and quality in New Zealand's educational provision. For example, TIMSS has contributed to a greater understanding of achievement and inequitable outcomes for two groups of New Zealand's student populations: Māori and Pasifika students.[49, 50]

In order to provide evidence of what works best for a range of diverse learners, the Ministry's Iterative Best Evidence Synthesis Programme (BES) was developed, with the first BES report released in 2003.[51] BES evaluates and synthesizes a wide range of New Zealand and international research, including TIMSS results. TIMSS research has been used in BES reports to inform educational policy and teacher practice and to suggest educational development approaches to optimize outcomes for learners.[52]

v Because New Zealand is a southern hemisphere country and the school year runs from February to December, we administered TIMSS 1995 during the last term of 1994. Similarly, TIMSS 2007 was administered during 2006.

Prior to the release of TIMSS 2007, much of the dialogue around the TIMSS results focused on mathematics achievement. However, the TIMSS 2007 results, along with those from the National Education Monitoring Project,[w] also brought attention to science education. The Royal Society of New Zealand, the New Zealand Association of Primary Science Educators, and the Education Review Office (ERO) all have taken action to try to address concerns raised by these two studies. In particular, ERO has undertaken research and written a report to exemplify good practices in primary science teaching.[53] As a result of ERO's experiences with this report, the quality of science teaching in upper primary schools was a focus area for ERO reviews during 2011.[54]

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Northern Ireland

Department of Education, Northern Ireland

Introduction

Overview of the Education System

Following devolution and the establishment of a local Assembly of Northern Ireland in 1999, legislative responsibility for education in Northern Ireland was devolved to the Assembly and to a locally elected Minister for Education. The Minister was responsible for a budget of £1.8 billion in 2011–12 to deliver high-quality education to 350,000 students in full-time education and other services, including early years education and youth services.

The Minister for Education sets policy direction and allocates resources, sets targets for the education system, and is accountable to the Assembly for outcomes. The Department of Education (DE) provides the central governance and management of education in Northern Ireland and is responsible for ensuring the effective execution of policies relating to the provision of education and youth services. The Minister's key priorities include raising educational standards for all and tackling underachievement wherever it occurs, with a particular focus on narrowing differences in outcomes between the most and least socioeconomically advantaged students.

The Minister for Education has a coherent set of policies in place designed to improve educational outcomes for young people and to address the root causes when students are not achieving to their full potential. These policies include the following:

- *Every School a Good School—A Policy for School Improvement*;
- *Count, Read: Succeed—A Strategy to Improve Outcomes in Literacy and Numeracy*;
- The revised curriculum and entitlement framework;
- The ending of academic selection;
- The Extended and Full Service Schools programs; and
- The Special Educational Needs and Early Years strategies (under development).

Every School a Good School—A Policy for School Improvement, published in April 2009, is based on a vision of schools as self-improving communities of good practice.[1] School self-evaluation and self-improvement (with support and, where necessary, challenge) are at the heart of the policy. The belief is that schools themselves, through honest and open engagement in self-evaluation and effective use of data available to them, are best positioned to identify and implement changes that lead to improvements for students. There is a particular focus on achievement in literacy and numeracy.

Count, Read: Succeed—A Strategy to Improve Outcomes in Literacy and Numeracy, published in March 2011, aims to support teachers and school leaders in their work to raise overall levels of attainment in literacy and numeracy among young people and to narrow the current gaps in educational outcomes.[2] The strategy includes milestone and long-term targets for improving outcomes in literacy and numeracy.

The Education and Training Inspectorate, under the DE, inspects and reports on the quality of education in preschool, school, and youth settings, and provides inspection services for other government departments. Inspection findings are available to parents and published on the Internet.

Over the last five years, educational standards achieved by students leaving school have improved. As of 2012, 43 percent of students now leave school with three or more grades A*–C at advanced level (A level) or equivalent qualifications (level 3 qualifications); and 59.5 percent now leave with at least five A*–C passing grades at the General Certificate of Secondary Education (GCSE) level or equivalent level qualifications, including GCSEs in English and mathematics (level 2 qualifications). The number of students leaving school with no formal qualifications has been reduced from 27 percent in 1980 to 2 percent in 2011.[3] Comparisons with other OECD countries via PISA show that 15-year-olds in Northern Ireland perform above average in science, and at the OECD average in literacy and mathematics.

Currently in Northern Ireland, 322,891 students attend education full-time.[4] In 2011–12, over 98 percent of students attended grant-aided schools (not including special schools), 1.4 percent attended special schools, and 0.2 percent attended non grant-aided independent schools.[5]

There are different types of grant-aided schools, with minor administrative differences, but all are funded through a Common Funding Formula. All grant-aided schools must provide the same curriculum, and parents can choose to apply to any school under open enrollment arrangements. Because of this parental choice, the majority of students are educated mainly with others of the same religious background (i.e., Protestant or Catholic). Spending decisions are delegated as much as possible to each school's Board of Governors in collaboration with the principal. There are also a very small number of independent schools that are not grant-aided by the DE.

The Department of Education also has a specific responsibility to encourage and facilitate the provision of integrated education, which aims to achieve a minimum percentage of both Catholic and Protestant students in each school, and Irish-medium education, where students learn through the medium of Irish.

Presently, five regional education bodies, known as Education and Library Boards (ELBs), are responsible for the effective provision of education in their local areas. The Education and Skills Authority, a single educational authority, will soon replace these bodies. In addition to providing education across all sectors and phases, the ELBs also act as the employing authority for all staff in managed schools and for all non-teaching staff in Catholic maintained schools. The Council for Catholic Maintained Schools promotes the effective governance and management of schools in the Catholic Maintained sector and is the employing authority for all teaching staff in these schools. Its functions also will be incorporated into the new Education and Skills Authority when it is established. Additionally, the *Comhairle na Gaelscolaíochta* and the Northern Ireland Council for Integrated Education receive funding from the Department of Education to support and provide a voice for the Irish-medium and integrated sectors.

Northern Ireland Executive's Programme for Government is committed to "ensure that at least one year of pre-school education is available to every family that wants it." [6] Funded preschool education is available in statutory nursery schools and units as well as in voluntary and private settings participating in the Pre-School Education Expansion Programme (PSEEP). This program incorporates a number of features designed to promote high quality preschool education provision in all settings, including a common curriculum for all those involved in preschool education, minimum accommodation requirements, minimum standards for staff qualifications and staffing levels, and support from a qualified teacher or early years specialist. All centers are subject to regular inspection.

Compulsory education extends from age 4–16, covering twelve years of schooling. This period of schooling is broken into phases, known as Key Stages, as illustrated in Exhibit 1.

Exhibit 1: Phases of Schooling, Ages 4–18

Level of Education	Stage	Years	Ages
Primary	Foundation Stage	1–2	4–6
	Key Stage 1	3–4	6–8
	Key Stage 2	5–7	8–11
Post-primary	Key Stage 3	8–10	11–14
	Key Stage 4	11–12	14–16
	Post-16 Provision (sometimes called Key Stage 5)	13–14	16–18

At the end of Year 7 (age 11), students in the Northern Ireland education system transfer from primary to post-primary school. Post-primary education consists of five years of compulsory education (Years 8–12, ages 11–16) and two further years if students wish to remain in school to pursue post-GCSE or Level 2 courses to Level 3.

As in the primary phase, post-primary students have a legal entitlement to a common curriculum. While the Minister's policy is that transfer should be on the basis of non-academic criteria, the law still allows for post-primary schools to admit students based on academic performance. Where there is oversubscription, each school sets its own criteria to select students, such as proximity of home to school, whether a sibling already attends the school, and ranking in the unregulated tests if they engage in academic selection.

Summary of National Curriculum

Legislation in Northern Ireland requires the provision of a statutory curriculum for all students that

> promotes the spiritual, moral, cultural, intellectual and physical development of all pupils at the school and thereby society: and prepares such pupils for the opportunities and experiences of adult life… [7]

From 2007, a revised statutory curriculum was introduced into all grant-aided schools on a phased basis with the following three key aims:

- To ensure that the core curriculum delivered in all grant-aided schools was relevant to the needs, aspirations, and career prospects of all young people;
- To promote a greater focus on skills and their applications as well as knowledge, and on connecting learning across the curriculum; and
- To reduce the prescription that had applied since 1989 and give teachers much more flexibility to exercise their professional judgment in planning and delivering lessons that were connected, relevant, and enjoyable, and which supported students in achieving their full educational potential.

All key stages, from Foundation to Key Stage 4, have statutory minimum content that must be covered in schools. Beyond that, schools have much greater freedom in what they cover and when it is covered.

The revised curriculum also has a particular focus on the core cross-curricular skills of communication (literacy), using mathematics (numeracy), and using ICT, as well as whole curriculum skills focusing on thinking skills and personal capabilities (often referred to as the "other skills").

Religious education also is a compulsory part of the curriculum in all grant-aided schools, although all schools must have arrangements in place for students whose parents do not wish them to receive religious education.

In primary schools, the curriculum also includes six areas of learning: language and literacy, mathematics and numeracy, the arts, the world around us, personal development and mutual understanding, and physical education. Though these study topics have been laid out in six discrete areas, teachers are encouraged to be flexible in selection and to integrate learning across the areas.

Standards of student competency in mathematics and numeracy are assessed through the cross-curricular skill of using mathematics, which describes the confidence and ability to apply mathematical skills in a range of meaningful contexts. New levels of progression have been established for all cross-curricular skills, written in the form of "can do" statements and designed to map the skills that pupils are expected to demonstrate by the end of each key stage (Key Stage 1 and 2 in primary education, and Key Stage 3 in post-primary education). New assessment arrangements designed to measure student progress in each of the cross-curricular skills are in the process of being implemented.

At Key Stage 3, the statutory curriculum is the same across all post-primary schools and includes religious education and the cross-curricular and "other" skills referred to above. The curriculum also includes the following areas of learning: language and literacy, mathematics and numeracy, modern languages, the arts, environment and society, science and technology, learning for life and work, and physical education.

At Key Stage 4, students are entitled to access a broad and balanced curriculum to meet their needs, interests and aspirations, regardless of the type of school they attend or its geographical location. Courses offered must have clear progression pathways to further or higher education, employment, or training. The Key Stage 4 curriculum must include religious education, physical education, the statutory content of the learning for life and work area of learning, and cross-curricular and "other" skills.

Students at Key Stage 4 must have access to, but are not required to take a qualification in, each of the eight areas of learning. The DE expects all students to take a General Certificate of Secondary Education course in mathematics and English unless there are exceptional and justifiable reasons why this would not be appropriate. While studying a science subject after the age of 14 is not compulsory, in recent years, particular effort also has been made to promote the benefits of STEM (science, technology, engineering, and mathematics)-related subjects and to encourage their uptake.

Success criteria, based on GCSE/Level 2 achievements, are normally applied for entry into Post-16 Provision courses (either 'A' levels or other equivalent Level 3 qualifications). Frequently, students select up to three or four subjects according to the results at GCSE or equivalent. For those who elect to continue their education, results in 'A' level or equivalent qualifications will determine entry into further or higher education colleges and universities for the training of sub degrees, or first degrees, including teacher training courses. Further studies lead to post-graduate qualifications at masters and doctorate levels, and at a higher level in preparation for a qualification to a professional body. Choices of progression route must be underpinned with access to high quality career education advice and guidance in order to ensure the most appropriate route to success.

Languages of Instruction

English is the official language and the language of instruction in the vast majority of schools in Northern Ireland, although a small but growing group of schools operates through the medium of Irish. The main minority ethnic groups in Northern Ireland, in which English would not be the first language spoken in the home, are, in order of size, Polish, Lithuanian, Slovakian, Latvian, Portuguese, Chinese, people from the Indian sub-continent of Pakistan and India, Hungarian, and Romanian.

Mathematics and science teaching is conducted in English in the vast majority of schools. In Irish-medium schools, instruction is provided in Irish with English as a separate subject. Although numbers have increased over previous years, the need for second-language instruction (other than Irish) is still relatively small. Some schools have obtained the support of personnel with bi-lingual skills in languages such as Polish and Portuguese. Many schools also have successfully adopted ICT translation strategies to assist in communicating with these students and their parents.

Mathematics Curriculum in Primary and Lower Secondary Grades

Mathematics is a discrete area of learning, and using mathematics (along with communication and using ICT) is a cross-curricular skill; as such, mathematics has a central place within the revised curriculum delivered in all grant-aided schools. The mathematics and numeracy area of learning focuses on the development of mathematical concepts and numeracy across the curriculum and detailed minimum content, which all schools must deliver, is set out in legislation. Additionally, the cross-curricular skill of using mathematics is designed to ensure that students acquire the skills of applying mathematical concepts, processes, and understanding appropriate in a variety of contexts. While students primarily develop these skills within the mathematics and numeracy area of learning, the curriculum ensures that students' skills and knowledge are applied to other areas and subjects.

Throughout the primary curriculum, students engage in a wide range of purposeful activities in mathematics, which involve many diverse skills. These skills include play, exploration, investigation, questioning, reflecting, recording, and discussion. Most mathematical skills are an integral part of life and the workplace, involving data handling, time, budget management, and organizing work and home situations. Students should develop mathematical processes through practical tasks, real life problems, and investigative activities. They should be able to understand number, notation, and number operations. They should understand appropriate use of calculation, estimation, and approximation. Students should be able to recognize patterns and sequences of numbers as well as relationships among numbers. Students are expected to measure and estimate quantities. They are expected to recognise two- and three-dimensional shapes by their properties and work with lines and angles. Lastly, students learn to collect, record, process, represent, and interpreting data.

From the beginning of primary education, numeracy and mathematics are introduced in appropriate contexts, in practical situations, and in stimulating environments. Students are encouraged to use knowledge, skills, and understanding in problem solving, talk about their conclusions, and explain their findings.

Attainment outcomes for mathematics at the primary education stage should enable students to develop knowledge, understanding, and skills in the following five areas: [8]

- Processes in Mathematics—Making and monitoring decisions, communicating mathematically, and mathematical reasoning;
- Number—Understanding numbers and number notation; patterns, relationships, and sequences in numbers; operations and their applications; and money;
- Measures—Measures of length, weight, volume and capacity, time, and area and temperature; relationships between units; perimeter, area, and volume; and scale in simple contexts;
- Shape and Space—Exploration of shapes; and position, movement, and direction; and
- Handling Data—Collecting, representing, and interpreting data; and introduction to probability.

Since 2007, students in Years 4–7 (ages 7–11) of primary education have completed statutory, computer-based assessments in mathematics. These diagnostic assessments are adaptive and are designed to support schools in identifying students' strengths and areas for improvement, as well as to inform the planning and delivery of teaching and learning in a way that helps students build on their strengths and address weaknesses at an early stage.

In lower secondary education, mathematics also is a statutory area of learning and pupils are expected to cover the minimum content set by law, supported through effective teaching by subject specialists from the beginning of Year 8. The curriculum for Key Stage 3 (ages 11–14) sets out minimum content in four domains: Number; Algebra; Shape, Space, and Measures; and Handling Data.[9] The expected learning outcomes for these areas indicate that students should be able to do the following by the end of this key stage:

- Solve simple problems with mental mathematics;
- Choose an appropriate method and equipment to solve problems (e.g., mental, written, calculator, mathematical instruments, or a combination of these);

- Demonstrate financial capability in a range of relevant everyday contexts;
- Research and manage information effectively to investigate and solve mathematical problems, using ICT where appropriate;
- Show deeper mathematical understanding by thinking critically and flexibly, solving problems and making informed decisions, using ICT where appropriate;
- Demonstrate creativity and initiative when developing ideas and applying them;
- Work effectively with others;
- Demonstrate self-management by working systematically, persisting with tasks, and undertaking self-evaluation with the goal of improving performance; and
- Communicate effectively in oral, visual, written, mathematical, and ICT formats, showing clear awareness of audience and purpose.

Science Curriculum in Primary and Lower Secondary Grades

At the equivalent of the grades tested in TIMSS (Grades 4 and 8, Years 6 and 10 in Northern Ireland), science and technology form part of the area of study known as The World Around Us (Year 6) and Science and Technology (Year 10).

In primary education, The World Around Us is designed to help students explore and find answers to questions arising from science, technology, history, and geography and form an appreciation of the wonders of the world and their place within it. In study of science in the context of The World Around Us, students have an opportunity to use their senses to develop their powers of observation, and an awareness of and use of ICT and thinking skills also is included. Students learn to ask for explanations of the nature of the world around them. They are offered the opportunity to look, sort, classify, explore, experiment, predict, compare, and plan. Through the contributory elements of history, geography, and science and technology, teachers enable students to develop knowledge, understanding, and skills in relation to four curricular areas: interdependence, place, movement and energy, and change over time.[10]

The science curriculum for Key Stage 3 (ages 11–14), the beginning of secondary school, describes minimum content in four science domains:[11]

- Organisms and Health—Interdependence of plants and animals; cells, genes and reproduction; and healthy body and mind;
- Chemical and Material Behavior—Atoms and chemical changes; structures, properties, and uses of materials; and elements, compounds, and mixtures;
- Forces and Energy—Forces and energy transfer, using electricity, and sound and light; and
- Earth and Universe—The environment and human influences on it, the solar system, and the universe.

Expected learning outcomes for these domains indicate that students should be able to do the following by the end of this key stage:

- Demonstrate a range of practical skills in undertaking experiments, including the safe use of scientific equipment, and appropriate mathematical calculations;
- Use investigative skills to explore scientific issues, solve problems, and make informed decisions;
- Research and manage information effectively, including use of mathematics and ICT where appropriate;
- Show deeper scientific understanding by thinking critically and flexibly, solving problems and making informed decisions, demonstrating use of mathematics and ICT where appropriate;
- Demonstrate creativity and initiative when developing ideas and applying them;
- Work effectively with others;
- Demonstrate self-management by working systematically, persisting with tasks, and undertaking self-evaluation with the goal of improving performance; and
- Communicate effectively in oral, visual, written, mathematical, and ICT formats, showing clear awareness of audience and purpose.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Materials, Equipment, and Laboratories

There are no specified programs or texts that schools must follow in the teaching of mathematics and science in the primary or secondary curriculum. Teachers work with a variety of textbooks and educational materials from various publishers. Much of each subject is taught through activities and practical work, so worksheets often are found in practice. Generally, classrooms are well equipped for practical lessons, with calculators and computers in use in most classrooms. Specialized science facilities, such as dedicated laboratories, are not found in primary schools. All post-primary schools are equipped for general science as well as specialized areas of science.

Use of Technology

ICT plays a central role in the curriculum, and using ICT as a cross-curricular skill is statutory across all key stages; emphasis is placed on using, applying, and transferring skills effectively in real and relevant contexts.

There has been a very significant investment in information and computer technology (ICT) in all schools in Northern Ireland. C2k provides all grant-aided schools with a core-managed service, including hardware, local area network services, wide area services, and management information systems.[12] Schools can add o the core provision by purchasing additional equipment using their delegated budgets.

A new five-year contract for C2k's service was put in place from April 2012. This new service takes account of developments in technology, such as the increasing use of personal smart mobile devices, the need for increased broadband width to accommodate bandwidth-hungry functions, and the move to central hosting (the "cloud"). As a result, major improvements in the use of digital technologies will be delivered to all grant-aided schools. The effective use of ICT in learning and teaching, while offering schools greater flexibility and choice, will have a positive impact on education standards and will help prepare students for the world of work.

Grades at Which Specialist Teachers for Mathematics and Sciences are Introduced

Generally, primary school teaching in Northern Ireland is undertaken by a classroom teacher. Subjects normally are taught as discrete disciplines or as part of project work. Specialist teachers for mathematics and science are introduced at Year 8, at the beginning of post-primary education.

Homework Policies

Individual schools manage homework policies and the Department of Education expects every school to have a written homework policy that is shared with parents. The length of time spent on homework varies depending on the nature of the assignment and the age and stage of the student. The DE provides guidance to primary schools and recommends that schools cooperate with parents to set a reasonable limit on the time their children spend on homework.

Primary schools rely on parents to help with and supervise their children's homework, especially at Key Stage 2 (ages 8–11). Secondary schools also encourage subject-based home study and independent research work.

Teachers and Teacher Education

Teacher Education Specific to Mathematics and Science

There are approximately 20,000 teachers employed in grant-aided schools in Northern Ireland. Teaching is an all-graduate profession, and teacher education is accessed at five higher education institutions (HEIs): Stranmillis and St Mary's University Colleges mainly cater to the primary sector through their Bachelor of Education (BEd) courses; and Queen's University Belfast, the University of Ulster, and the Open University cater to the post-primary sector through their Postgraduate Certificate in Education (PGCE) courses.[a, b]

A Bachelor of Education takes four years to complete, involving professional tuition and academic study in one or more specialist subjects. Alternately, students who have completed a three- or four-year Bachelor of Arts (BA) or Bachelor of Science (BSc) degree may then apply to attend the PGCE course of study. Normally, Bachelor of Education courses of study consist of academic studies, professional tuition, and classroom-based teaching practice. Upon successful completion of an initial teacher education degree, teachers are granted "eligibility to teach" status and are eligible for registration with the General Teaching Council for Northern Ireland. A newly qualified teacher must undertake an induction program, normally lasting one year, followed by a two-year program of Early Professional Development. The arrangements for initial teacher education and continuing professional development in Northern Ireland are currently under review.

Most post-primary science teachers complete a three-or four-year general science degree before applying for post-graduate teacher education. Their professional development normally takes place while on placement in science departments in post-primary schools.

a Details of course provision in each of the HEIs can be found in the Department of Education leaflet, retrieved from http://www.deni.gov.uk/index/school-staff/teachers-teachinginnorthernireland_pg/10_teaching_in_northern_ireland-initial_teacher_education-pg.htm

b Entry requirements for ITE programs are detailed in the DE Circular 2010/03, *Initial Teacher Education: Approval of Programmes*, retrieved from http://www.deni.gov.uk/ite_approval_of_programmes_circular_-_english_version-2.pdf

Requirements for Ongoing Professional Development

Currently, in-service training may be center- or school-based depending on school and teacher needs. Education initiatives arising from the Department of Education or the Curriculum Council are normally delivered by the Regional Training Unit or by the Curriculum Advisory Support Service teams of the five Education and Library Boards. A single School Development Service is currently in development; it is envisaged that, in the future, professional development will be facilitated and commissioned through this support structure. School managers also may initiate school-based professional development on education issues, with or without the assistance of Curriculum Advisory Support Service advisory officers. Generally, this professional development will be for issues pertinent to individual staff groups and normally is paid for from the individual school budget. Many small rural schools arrange cluster groups to disseminate information, provide staff training, and share good practice.

Monitoring Student Progress in Mathematics and Science

Assessment of student progress in the areas of learning and "other skills" elements of the curriculum is delegated to schools, and information on student progress is not collected centrally. The Council for the Curriculum, Evaluation and Assessment (CCEA) provides advice and exemplars of good practice, allowing schools and teachers a high degree of flexibility in exercising their professional judgement.

Student progress in the cross-curricular skills of using mathematics and communication (and, from 2013–14, using ICT) is assessed annually by teachers and the information used to inform teaching and learning in school and reported to parents. At the end of Key Stages 1, 2, and 3 (Years 4, 7, and 10), teachers assess and report on children's literacy and numeracy skills against levels of progression. Assessment is completed by the teacher, informed by the outcomes of a series of tasks and classroom observations. Due to the importance of monitoring and improving performance in the cross-curricular skills, information about student performance at the end of each key stage is collected centrally and used both as a system measure and for accountability purposes.

In primary education, over 80 percent of children reach their expected level in both literacy and numeracy for their age. In 2010–11, 82.4 percent reached the expected level in English, and 82.9 percent achieved it in mathematics. The Minister of Education has set 2020 student literacy and numeracy expected level achievement targets at over 90 percent.

At the end of Key Stage 3 (age 14), statutory assessment is completed in English and mathematics, as well as in Irish for Irish-medium schools. Students who have statements of special needs and who have been assessed as having severe learning difficulties are exempted from statutory assessment.

Summative assessment at the end of Key Stage 3 is carried out by the classroom teacher to determine the level achieved by each student. Outcomes are then transferred electronically to CCEA by electronic data interchange. Class and school statistics are returned to the school and individual outcomes are reported to parents.

Beginning in the 2012–13 school year, using mathematics will be assessed with reference to new levels of progression which focus on skills as well as knowledge. This assessment will be via a robust model of moderated teacher-led assessment. It should be noted that the assessment and reporting of a student's progress in using mathematics must take into account the student's achievements in the mathematics and numeracy area of learning.

Parents can elect for their Year 7 (age 11, end of Key Stage 2) students to take unregulated examinations in English and mathematics. While the majority of post-primary schools do not use academic admissions criteria, many traditionally selective schools (largely but not exclusively grammar schools) still admit their students based on examination results.

Using statistics generated over previous years in mathematics, 72.9 percent of Key Stage 3 students achieved the expected level in 2005–06, 74.4 percent reached the expected level in 2006–07, and 77.3 percent in 2010–11. In 2012, the expected level was 76 percent, and in 2020, 85 percent will be expected to achieve this level.

At age 16, after completing 12 years of compulsory education (end of Key Stage 4), students take the General Certificate of Secondary Education or equivalent level examinations in the courses (subjects) they have studied at Key Stage 4. National targets have been set to encourage the raising of standards across all schools. In the 2012 school year, 61 percent of students will be expected to achieve five GCSE grades in the A*–C range, including English and mathematics. The target for 2020 has been set at 70 percent. The percentage of students receiving free school meals (the indicator used to determine social deprivation) expected to achieve five GCSE grades in the A*–C range is currently 31.7 percent (target is 65 percent by 2020).

Students who return post-GCSE normally study 'A' levels or equivalent Level 3 qualifications. The outcome of assessment in these subjects will help determine their future progress in education, training, or employment.

Impact and Use of TIMSS

Currently, 17.6 percent of those leaving primary school are performing below the expected level in numeracy. However, according to the Department of Education, as of 2011, no information has been available to allow Northern Ireland to make international comparisons in the primary grades.

To address this shortfall in benchmarking information, schools have participated in TIMSS 2011 to assess the performance of nine- and ten-year-olds (Year 6) in numeracy and science. This study also will provide data on attitudes, home factors, access to computers, and other factors which influence achievement; this data will allow Northern Ireland to identify areas for improvement in primary provision, and should assist education policy makers in ensuring that students leave primary schools with the appropriate skills in numeracy and science.

Suggested Reading

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Norway

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Introduction

Overview of the Education System

Norway has a centralized curriculum comprising all subjects for Grades 1–13. The Parliament approves the curriculum through a process initiated by the Ministry of Education and Research and involving expert groups. Within the frameworks set by the curriculum, local schools and teachers have considerable freedom to make their own decisions about organization and instructional methods.

Kindergarten or preprimary school is neither compulsory nor free in Norway, though every child has a right to attend. Following preprimary, every child has the legal right to 13 years of education, of which the first ten grades (Grades 1–10) are compulsory and free. The next three years (Grades 11–13) are not compulsory but are still free. Children enter Grade 1 in August of the year when they reach the age of six. Most students are enrolled in public schools; private schools play a small role in Norwegian education.[1]

Norwegian education is divided into three main stages. Primary school (Grades 1–7) is called the Child Stage, while lower secondary school (Grades 8–10) is called the Youth Stage. Together, these stages constitute compulsory education, called Basic School. In Basic School, there are very few alternative programs and no streaming; almost all students are taught together in regular classes in all subjects. This system results from a broad political agreement on not creating unnecessary differences between children.

The final three grades, Grades 11–13, constitute (upper) Secondary School. Although this level is not compulsory, it is attended (or attempted) by the vast majority of the youth cohort. Certain basic subjects are common for all students. However, students choose between a variety of general study programs which prepare them for tertiary studies and vocational programs.

In 2006, a new curriculum—Knowledge Promotion—was introduced. Knowledge Promotion retained the basic educational visions supporting previous curricula but, for the first time, provided a comprehensive curriculum for the entire Norwegian school system. This new curriculum became fully implemented by 2008 and includes goals written as statements of competencies to be attained, and introduces a competency called basic skills.[2, 3, 4, 5]

Mathematics has a prominent place in the Norwegian school curriculum; together with Norwegian and English, it is one of the core subjects covered by national examinations in Grade 10. Much less instructional time is allocated to science during compulsory education, and there is no national examination in science in Grade 10. However, the 2006 curriculum reform increased the amount of time allocated to both mathematics and science in the lower grades.

Languages of Instruction

Norwegian is the main language spoken in Norway, and is the dominant language of instruction at all levels of education. The Sámi population speaks and writes three Sámi languages and, in certain schools, Sámi is the language of instruction. Immigrant students may learn mother-tongue languages in addition to Norwegian. Also, English is taught as a foreign language beginning in Grade 1. (For more about language in the Norwegian school system, see the *PIRLS 2011 Encyclopedia*.[6])

The Norwegian Curriculum in Basic and Secondary Schools

The Norwegian curriculum is organized by groups of grades, and curriculum goals specify competencies to be attained by the end of Grades 2, 4, 7, 10, 11, 12, and 13. The competency goals for Grade 4 can easily be compared to the *TIMSS 2011 Assessment Frameworks*[7] for the fourth grade. For Grade 8, however, there are no specific curricular goals; at this stage goals are combined for Grades 8–10. In addition, the order in which subject areas for these grades are presented may vary across schools and textbooks. Hence, statements about the Grade 8 curriculum in Norway can only give a general indication of what is covered.

For each school subject, the curriculum includes an introduction about the general objectives and structure of the subject, specifications for basic skills in that subject, a list of competency goals, and finally, some statements about assessment. There are no statements about topics to be covered, only about competencies to be attained.

Mathematics Curriculum in Primary and Lower Secondary Grades

A brief overview of the mathematics curriculum for Grades 1–10 is as follows.[8]

The first sentence in the curriculum states that "Mathematics is part of our global cultural heritage." [9] After presenting mathematics as a possible source of joy, the curriculum emphasizes the broad range of applications and utility. Concrete and practical as well as abstract and theoretical aspects of mathematics are mentioned, and must have a place in the teaching and learning of the subject.

The mathematics curriculum is organized into main areas. For Grades 1–4, these areas are Numbers, Geometry, Measuring, and Statistics. The main areas for Grades 5–7 are Numbers and Algebra, Geometry, Measuring, and Statistics and Probability. In Grades 8–10 the curriculum is organized into the following: Numbers and Algebra; Geometry; Measuring; Statistics, Probability, and Combinatorics; and Functions.

Five basic skills are defined across all subjects and grades in the curriculum. (Work is ongoing to improve these definitions.) For mathematics, the present descriptions include the following:

- Oral skills—Asking questions, reasoning, arguing, explaining ideas, and discussing solution strategies;
- Writing skills—Describing thought processes; explaining discoveries and ideas; and using symbols, drawings, tables, and graphs;
- Reading skills—Interpreting texts with mathematical expressions, graphs, tables, symbols, formulas, and logical reasoning;
- Numerical skills—Gaining familiarity with mathematical operations and estimates, exploration, problem solving, and variation of strategies; and
- Digital skills—Using digital tools for exploration, visualization, publication, simulation, and modeling and information collection, as well as for analysis, processing, and presentation of data—all with a critical attitude toward sources, analyses, and results.

Exhibit 1 presents the competencies which students are expected to be able to attain in mathematics at Grades 1–4, Grades 5–7, and Grades 8–10. As a general indication, it might be expected that the most elementary third of the goals for Grades 8–10 should be attained in Grade 8.

Exhibit 1: Expected Competencies in Mathematics, Grades 1–10

Grade Range	Expected Competencies
Grades 1–4	Use the real number line, describe the place-value system, and use positive and negative integers, simple fractions, and decimal numbers; add, subtract, and estimate both mentally and on paper; use multiplication tables, carry out multiplication and division, and exploit simple relations between arithmetic operations; and experiment with, recognize, describe, and work with simple number patterns. Recognize, sort, and describe characteristics of geometric figures; recognize and use mirror symmetry and translation; make, explore, and describe geometric patterns; and place and describe positions in grids, on maps, and in coordinate systems. Estimate and measure length, area, volume, mass, temperature, time, and angles; compare magnitudes and convert units. Collect, sort, record, illustrate, and comment on data using tallies, tables, and bar charts.
Grades 5–7	Calculate with positive and negative integers, decimal numbers, fractions, and percentages; find common denominators; use a calculator and a spreadsheet for simple calculations; justify solution methods; and explore and describe structures in simple numerical and geometrical patterns. Analyze characteristics of two- and three-dimensional figures, build three-dimensional models, and draw simple three-dimensional figures in perspective; describe and perform reflection, rotation, and translation; describe position and movement in a coordinate system; and calculate distances parallel to the coordinate axes. Select suitable measurement tools, choose suitable units, and convert between units; explain measurements of area and volume and calculate circumference, area, surface area, and volume of simple two- and three-dimensional figures; use a scale to calculate distances from a map and to make a scale drawing; use proportions in practical situations; calculate velocity; and convert currencies. Collect data from observation, questionnaires, and experiments; represent data in tables and graphs, digitally and manually; read, interpret, and assess data; find median, mode, and average for simple datasets, and assess them in relation to each other; assess probability in everyday contexts, games, and experiments; and calculate probability in simple situations.
Grades 8–10	Compare and convert integers, decimal numbers, fractions, and percentages; divide and reduce fractions; use factors, powers, square roots, and prime numbers in calculations; factor simple algebraic expressions; work with formulas, parentheses, and rational expressions with a single term in the denominator; solve linear equations and inequalities and simple systems of equations with two unknowns; and prepare simple budgets and do calculations about private finances. Analyze characteristics of geometric figures and use them for constructions and calculations; carry out and explain constructions with a compass, ruler, and other tool; use congruence and the Pythagorean theorem to calculate unknown lengths and angles; make and interpret scale drawings and perspective drawings; use coordinates to represent figures; and formulate logical reasoning about geometrical ideas. Discuss precision and uncertainty of measurements; account for the number π, and use it in calculations of circumference, area, and volume. Carry out investigations and use databases to analyze statistical data and demonstrate critical assessment of data sources; order and group data; find and discuss median, mode, average, and range; present data with and without digital tools; find probabilities by experiments, simulations, and calculations in everyday contexts and in games; describe sample spaces and express probabilities as fractions, percentages, and decimal numbers; and provide examples of and solve simple combinatorics problems. Construct functions that describe numerical relationships and practical situations, interpret the functions, and convert between various representations of functions, such as graphs, tables, formulas, and text; identify and apply properties of proportional, inversely proportional, linear, and simple quadratic functions, and provide examples of practical situations that may be described by these functions.

Science Curriculum in Primary and Lower Secondary Grades

A brief overview of the science curriculum for Grades 1–10 is as follows.[10]

Knowledge and understanding of natural science is a basis for participation in democratic processes and enables people to contribute to sustainable development, and learning science must be closely related to practical experience in laboratories and nature. The first sentence in the curriculum states that "Natural science is the result of human curiosity and our need to find answers to questions about our existence, life and life forms, and our place in nature and the universe, and, in this way, it becomes part of our culture." [11] The curriculum emphasizes the holistic nature of the subject even though natural science is divided into the disciplines of physics, chemistry, biology, and the geosciences. The curriculum also states that scientific laws and theories are models of reality and that these laws and theories develop through observations, experiments, and ideas. In short, the science curriculum has a profile emphasizing both the content and nature of science.

The natural science curriculum for Grades 1–10 is organized into six main areas: the Budding Researcher, Diversity in Nature, Body and Health, the Universe, Phenomena and Substances, and Technology and Design.

Five basic skills are defined across all subjects and all grades in the curriculum. (Work is ongoing to improve these definitions.) For natural science, the present descriptions include the following:

- Oral and writing skills—Presenting and describing experiences and observations from nature; writing reports from experiments, fieldwork, and excursions; and formulating questions and hypotheses;
- Reading skills—Interpreting and reflecting on natural science texts from the Internet and in books, newspapers, brochures, manuals, recipes, tables, and diagrams;
- Numerical skills—Recording and calculating results from measurements; organizing tables and diagrams; and using and interpreting formulas and models; and
- Digital skills—Using digital tools for exploration, measurement, visualization, simulation, animation, registration, documentation and publication; and critical assessment of Internet-based information.

Exhibit 2 presents the competencies which students are expected to be able to attain in natural science at Grades 1–4, Grades 5–7, and Grades 8–10. As a general indication, it might be expected that the most elementary third of the goals for Grades 8–10 should be attained in Grade 8.

Exhibit 2: Expected Competencies in Natural Science, Grades 1–10

Grade Range	Expected Competencies
Grades 1–4	Explore the local neighborhood, ask questions and talk about experiences in nature, and describe observations; use simple measuring instruments to collect and organize data; and present results.
	Recognize, sort, and describe some species of plants and animals and describe their life cycles; describe some important characteristics of the four seasons; observe and note what happens to trees and other perennial plants over time; describe some extinct animal species; discuss the benefit of animal welfare; and argue for appropriate behavior in nature.
	Name and describe the function of some external and internal body parts and senses; talk about the development of the human body from conception to adulthood; describe some common childhood diseases and define inoculation; observe and describe how the human body reacts in a number of situations; and discuss emotional experiences and reactions and the relationship between physical and mental health.
	Describe how the Earth, moon, sun and planets move in relation to each other; and observe and describe the seasons, day and night, and different phases of the moon.
	Sort substances according to easily observable characteristics and describe these characteristics; perform experiments with water, air, sound, and light and talk about observations made; describe how and discuss why people sort waste; provide an example of a biological cycle involving decomposition; carry out experiments showing that substances may change their nature when subjected to various influences; and observe and describe weather and clouds and measure temperature and precipitation.
	Make objects that can be propelled by water or air and objects that use reflection of light, and discuss the objects; plan, build, and test simple models of building constructions and document the process; describe building structures and discuss why some are more stable than others; and compare load-bearing structures in buildings in the local neighborhood
Grades 5–7	Formulate questions and hypotheses, prepare a plan for examining a hypothesis, conduct the examination, and publish and discuss the results; explain the importance of making and testing hypotheses through systematic experiments and observations; and extract natural science information from simple scientific texts in different media.
	Plan and conduct explorations in nature, examine and describe plants and explain the functions of different parts of the plant, and examine and describe factors that influence the germination and growth of plants; describe characteristics of vertebrates and explain the functions of the most important organs; describe characteristics of some plants, mushrooms, and animals and tell how they are ordered systematically; and discuss traditional uses of some plants, mushrooms, and animals.
	Describe the most important organs in the human body and their functions; describe the human skeleton and muscles and explain how the body can move; explain what happens during puberty and talk about gender identities and variation in sexual orientation; and collect information about and discuss damage to health caused by drug abuse.
	Describe the solar system and scientific theories about the origin of the Earth; describe a model of the solar system and discuss how the model may explain observed phenomena like night and day, lunar phases, and the sun's motion across the sky.

Grade Range	Expected Competencies
	Examine and describe main characteristics of some minerals and rocks and how they have been formed; carry out experiments with sound, hearing, and noise and with magnetism and electricity, and describe and explain the results; account for the use of some sources of energy in earlier times and in the present, and describe consequences of this use for the global and local environments; carry out relevant weather measurements; describe the main characteristics of gases, liquids, solids, and use the particle model to explain phase transitions; use the concepts of atoms and molecules to explain the structure of substances and how substances may be transformed; and carry out experiments with chemical reactions and explain what characterizes these reactions. Plan, build, and test mechanical toys, and describe various movements of the toys and the principles of mechanical transfer; plan, build, and test simple products that use electricity, and explain how they work; and account for how transfer of motion has been used throughout history to exploit energy in wind and water.
Grades 8–10	Plan and conduct experiments to test the validity of hypotheses; keep records during experiments and fieldwork and present reports; explain the importance of looking for relationships between cause and effect and explain why arguments, disagreement, and publication are important; and demonstrate protective and safety equipment as well as safety procedures in science instruction. Describe the structure of animal and plant cells and explain the main features of photosynthesis and respiration; explain cell division, genetic variation, and inheritance; explain the main features of the theory of evolution and the basis for this theory; explain main features of theories about how the Earth changes and has changed through history, and the basis for these theories; account for biotic and abiotic factors in an ecosystem and explain the relationship between the factors; and observe and provide examples of how human activities have affected a natural area, identify views of different interest groups, and propose measures that may preserve nature for future generations. Discuss issues related to sexuality, different sexual orientations, contraception, abortion, and sexually transmitted diseases; explain how the human body protects itself against disease and describe how to prevent and treat infectious diseases; explain how the nervous system and the endocrine system control bodily processes; describe the development of a fetus and the process of birth; account for how lifestyle choices may lead to disease and injury and how this may be prevented; provide examples from popular medicine and discuss the difference between alternative and academic medicine; and account for how drug abuse may damage health and discuss how this can be prevented. Describe the universe and different theories of how it has developed; provide an overview of technological equipment used in exploring space, present important events from the history of space travel, and discuss research investigating possibilities of life on other planets; and describe the apparent motion of planets across the sky and explain how solar and lunar eclipses occur. Assess properties of elements and compounds by using the periodic table; carry out experiments in order to classify acidic and alkaline substances, separate substances in a mixture, and analyze an unknown substance; examine the chemical properties of some common everyday substances, and plan and conduct experiments with hydrocarbons, alcohols, carboxylic acids, and common carbohydrates, and describe them; explain the origin of crude oil and natural gas and how they are used; explain results from experiments with electric circuits using the concepts of current, voltage, resistance, power, and induction; explain how we can produce electrical energy from renewable and non-renewable sources; explain the concepts of velocity and acceleration, measure their magnitudes with simple tools, and provide examples of how force is connected to acceleration; carry out experiments and simple calculations with work, energy, and power; explain how traffic safety equipment prevents and reduces injuries in accidents; and carry out experiments with light, vision, and colors, and describe and explain the results; and Develop products that use electronics, evaluate the design process, and assess product functionality and user-friendliness; test and describe properties of materials used in a production process; and explain electronic communication systems at a systems level, and discuss societal challenges connected to using them.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Materials, Equipment, and Laboratories

Textbooks or teaching materials are no longer centrally mandated, recommended, or approved. There are some recommendations on science laboratory equipment, and security regulations for science laboratories.

Use of Technology

The new 2006 curriculum introduced the concept of basic skills, one of which is being able to use digital tools. It is therefore expected that every teacher in each subject and grade will apply digital tools and develop students' skills with them. What to use and how to use it, however, is largely left to the teacher or school to decide.

In mathematics, students use calculators, spreadsheets, and various specialized programs, like GeoGebra. Most students use calculators in their daily work with mathematics. The type of calculator used is a local choice. Calculators are allowed in a part of the final, national examination.

In science, students use calculators, data loggers, and simulations, among other technology tools. Reports often are written on computers and information frequently is collected from the Internet. In some schools, students are equipped with portable computers.

Grade at Which Specialist Teachers for Mathematics and Science Are Introduced

Until recently, general teachers in Norway were educated in teacher colleges and deemed qualified to teach all subjects at all levels in Basic School (Grades 1–10). University-trained specialist teachers were deemed qualified to teach their subjects (usually two) in Secondary School (Grades 11–13). Consequently, almost all Norwegian students have been taught by general teachers in primary school (Grades 1–7) and by specialist teachers in upper secondary school (Grades 11–13). In lower secondary school (Grades 8–10), there has been a mixture of general and specialist teachers.

In 2010, general teacher education for Basic School was reformed and was divided into two study programs: one program for general teachers in Grades 1–7, and another program for specialist teachers in Grades 5–10.

Homework Policies

Norway has no regulations governing homework and out-of-class assignments. However, opportunities to receive learning support at home differ, partly due to socio-economic factors. Because this may be considered unfair, initiatives to offer homework support at school have begun.

Teachers and Teacher Education

Teacher Education Specific to Mathematics and Science

Enrollment in general teacher education programs requires successful completion of upper secondary school. Since 2006, additional admission requirements include passing grades in Norwegian and mathematics (a grade of at least 3 on a scale from 1, failing, to 6, excelling). In order to be admitted to a teacher education program in mathematics or science at a university, students must have completed a certain amount of upper secondary school specialization in these subjects. In order to meet requirements to become a teacher, students must complete at least 60 credits (i.e., one year of full-time university study) in each of their chosen subjects.

Teacher education programs require at least 30 credits (equivalent to one full-time semester) in mathematics, including both mathematics and mathematics pedagogy; additional credits are optional. There are no similar requirements in science.

Since 2008, employment regulations require teachers to have completed 60 credits in Norwegian, mathematics, or English to teach those subjects in lower secondary school. To teach other subjects, such as science, teachers must have completed 30 credits.

Requirements for Ongoing Professional Development for Teachers

Teacher professional development is the responsibility of school administrators (i.e., district or regional authorities). Schools receive funds to support in-service education from the government, but have the freedom to prioritize the types of professional development offered; thus, there are large variations in teacher professional development throughout Norway. The majority of courses for teachers are offered by universities or colleges.

Monitoring Student Progress in Mathematics and Science

At the end of compulsory school (Grade 10), students receive one overall achievement grade in each subject, determined by the school. In addition, students are selected for one written examination. Approximately one-third of students are selected to take an examination in mathematics, one-third in Norwegian, and one-third in English. The written examination is prepared and scored at the national level. Students also may be selected for an oral examination that is prepared and scored locally.

Norway also has national tests in mathematics, reading, and English administered early in Grades 5 and 8. These tests are constructed on a national basis but are scored locally.

Teachers regularly write progress reports on all their students, but grades are not given until lower secondary school. Parents are regularly summoned for meetings in school.

The Ministry of Education and Research funds a test-construction website for composing tests with predefined content, and textbook publishers sometimes offer suggestions for classroom tests.[12] However, tests typically are written locally.

Impact and Use of TIMSS

Norway participated in TIMSS 1995, 2003, and 2007 as well as in TIMSS Advanced 1995 and 2008. Norway also has participated in PISA and TEDS-M. Outcomes from these studies have received publicity and attracted professional, political, and public interest. Issues raised in the reports from these studies have initiated public debates, and the Ministry of Education and Research appointed a commission to discuss the educational situation in the country. This resulted in significant curriculum reform of the entire school system in 2006.

Generally, TIMSS and TIMSS Advanced have been influential in setting the agenda for educational discussions in Norway, as well as for actions taken to improve student achievement in mathematics and science. National reports from TIMSS and TIMSS Advanced have concluded that too little attention is given to pure, formal mathematics, such as arithmetic and algebra. It also has been noted that individual student work is the main instructional strategy in Norway, with little use of other important strategies, such as training in basic skills and discussions, and reflections on concepts and solutions. In the new curriculum, basic skills are established as a central theme. The importance of basic skills for learning has been stressed by various groups in Norway, but the TIMSS national reports also influenced the conversation.

Similarly, TIMSS reports have illuminated concerns about the consequences of widespread calculator use in mathematics classrooms and related problems with organizing tests and examinations. Until recently, Norwegian students had been allowed to use a variety of aids, such as calculators and notes, to assist them on tests and examinations. Debates on this issue resulted in a new organization of national mathematics examinations, requiring the first part of the examination to be completed without any aids; the second part still allows several aids.

An important curricular goal in Norway is that all students shall receive instruction in accordance with their potential for learning. TIMSS results have focused attention on taking the needs of high-achieving students seriously and on supporting these students to a similar extent as low-achieving students. From a national perspective, this is important in the ongoing discussion regarding student recruitment for mathematics and science professions.

Analyses of data from TIMSS studies also have been influential in debates about homework, addressing the fact that classes spending more time on homework review show higher achievement than classes spending less time. The importance of teacher feedback on homework also has been highlighted as an issue because of TIMSS results.

Suggested Readings

The last national reports from TIMSS, TIMSS Advanced, and TEDS-M draw a rather comprehensive picture of mathematics and science in Norwegian education:

Grønmo, L.S. & Onstad, T. (Eds.). (2009). *Tegn til bedring. Norske elevers prestasjoner i matematikk og naturfag i TIMSS 2007* [Signs of improvement. Performance by Norwegian students in mathematics and science in TIMSS 2007]. Oslo: Unipub. Retrieved from http://www.timss.no/rapport2007/Hele_TIMSS2007.pdf

Grønmo, L.S., Onstad, T., & Pedersen, I.F. (2010). *Matematikk i motvind. TIMSS Advanced 2008 i videregående skole* [Mathematics against headwinds. TIMSS Advanced 2008 in upper secondary school]. Oslo: Unipub. Retrieved from http://www.timss.no/rapporter%202008/Matematikk%20i%20motvind.pdf

Lie, S., Angell, C., & Rohatgi, A. (2010). *Fysikk i fritt fall? TIMSS Advanced 2008 i videregående skole* [Physics in free fall? TIMSS Advanced 2008 in upper secondary school]. Oslo: Unipub. Retrieved from http://www.timss.no/rapporter%202008/TIMSS_Advanced_Fysikk.pdf

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Grønmo, L.S. & Onstad, T. (Eds.). (2012). *Mange og store utfordringer. Et nasjonalt og internasjonalt perspektiv på utdanning av lærere i matematikk basert på data fra TEDS-M 2008* [Many and great challenges. A national and international perspective on education of mathematics teachers based on data from TEDS-M 2008]. Oslo: Unipub. Retrieved from http://www.timss.no/

A common report in English with emphasis on TIMSS and TIMSS Advanced in Norway, Slovenia, and Sweden is planned.

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7 Mullis, V.S., Martin, M.O., Ruddock, G.J., O'Sullivan, C.Y., & Preuschoff, C. (2009). *TIMSS 2011 Assessment Frameworks*. Chestnut Hill, MA: TIMSS & PIRLS International Study Center. Retrieved from http://timssandpirls.bc.edu/timss2011/downloads/TIMSS2011_Frameworks.pdf

8 Norwegian Directorate for Education and Training. (n.d.). *Common core subjects in primary and secondary education—"Mathematics*." Retrieved from http://www.udir.no/Stottemeny/English/Curriculum-in-English/_english/Common-core-subjects-in-primary-and-secondary-education/

9 Ibid.

10 Norwegian Directorate for Education and Training. (n.d.). *Common core subjects in primary and secondary education–"Natural science*." Retrieved from http://www.udir.no/Stottemeny/English/Curriculum-in-English/_english/Common-core-subjects-in-primary-and-secondary-education/

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Oman

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Introduction

Overview of the Education System

Between 1970 and 2010, the education system greatly expanded in the Sultanate of Oman. In 1970, 30 teachers taught just 909 students in the country's three schools. By 2010, 523,255 students were being taught by 45,273 teachers in 1,040 schools. There are now also three additional schools for Special Education, with 196 teachers serving 577 students.[1, 2]

In the early 1970s, the Sultanate's education service depended heavily on teachers from neighboring Arab countries such as Egypt, Jordan, and Tunisia. In addition, Britain and countries from the Indian subcontinent provided English language teachers. In 1976, training programs for both male and female Omani teachers began. Since then, there has been an effort, known as "Omanization," to prepare Omanis to hold positions in all ministries as well as the private sector, including the posts of teachers and administrators within the Ministry of Education (MoE). In 1980, only approximately 8 percent of teachers were Omani; but with Omanization, by 2010 this increased to approximately 89 percent, with 100 percent of IT teachers being Omani. Similarly, Omanis now constitute approximately 95 and 99 percent of supervisors and administrators, respectively, according to 2010 statistics.[3]

Historically, Oman's education system has been highly centralized, with MoE making the majority of decisions affecting the country's schools. However, the ministry is currently attempting to decentralize by granting authority to the eleven regional offices of education to handle most administrative functions.

In addition, in 1998, MoE began a reform project to convert the existing general education system, which emphasized teacher-centered, passive learning, and high-stakes examinations, into a student centered, active-learning pedagogy with an emphasis on formative continuous assessment termed "Basic Education." Each level of Basic Education provides 180 school days and 1,600 minutes of instruction per week. Importantly, Basic Education has significantly increased time spent on teaching mathematics, science, and computer technology skills. Furthermore, MoE has established national tests for mathematics, science, English, and Arabic for Grades 4, 7, and 10.

The structure of the Basic Education system is as follows:

- Cycle One (Grades 1–4)—Co-educational;
- Cycle Two (Grades 5–10)—Separate boys' and girls' schools; and
- Post Basic (Grades 11–12)—Separate boys' and girls' schools.[4]

Conversion to Basic Education is more than 79 percent complete. However, the old general education system continues to operate in Grades 5–8 while the transition continues. The popularity of the Basic Education pedagogy has resulted in many general education schools adopting Basic Education resources and teaching techniques. For example, because activity-based learning is central to Basic Education, resources for hands-on activities are incorporated into the mathematics and science curricula to support active-learning classrooms.

The ministry also has reorganized a program for Grades 11 and 12, called "Post Basic Education," which was first implemented in the 2007–2008 school year. This program offers a set of mandatory courses and a selection of courses as electives, providing students with a choice of pathways. To assist students in choosing among the pathways, the ministry established a Center for Career Guidance and provided career counselors at all schools teaching Grade 10 and above.

Concurrent to systemic reforms, the ministry has embarked on ambitious, though costly, projects to significantly improve facility development, resource procurement, teaching workforce development, and curriculum change. In terms of workforce development, there is a strong desire to increase the use of computer technology in schools, both as part of computer literacy programs and as productivity tools to be used in multiple subjects. While an expensive undertaking, the ministry has trained Omani teachers to enable them to teach IT. However, the continuing growth of the number of students, teachers, and schools poses further challenges to the system.

One of the most important educational programs recently developed resulted from a directive of His Majesty Sultan Qaboos bin Said—the Cognitive Development Program for Students in Science, Mathematics, and Environmental Geography Concepts. Launched in the 2007–08 school year, the program encourages students to acquire knowledge, improve achievement, and enhance the study of practical aspects of science, mathematics, and environmental geography. The program is based on oral contests, student projects, written tests, and supporting activities, each encouraging students to conduct research and investigations, practice systematic scientific thinking, and develop their innovation capabilities. The program has established objectives for learners, teachers, and the educational system in general:

- For Learners—Motivating students to study science, mathematics, and environmental geography concepts in order to achieve an appropriate balance at Grades 11 and 12 between achievement in the sciences and humanities disciplines and the requirements of an evolving society; and improving student achievement in science, mathematics, and environmental geography concepts, and enhancing study of the practical components of these subjects.
- For Teachers—Motivating teachers to improve their performance and preparation to instruct learners at multiple levels within the same classroom; encouraging teachers to follow developments and discoveries in science, mathematics, and environmental geography as well as promoting scientific competitiveness; and developing professional skills (e.g., the teaching of higher-order skills) through various centralized and non-centralized training programs.
- For the Educational System—Achieving the objectives of education adopted by MoE since the implementation of the Basic Education system and enhancing the ministry's provision for applied sciences; providing tools to evaluate levels of achievement and performance in science, mathematics, and environmental geography; and enabling teachers and learners to use the environment as a learning resource and a field for applying scientific knowledge.

Languages of Instruction

Classical Arabic is the official language of the Sultanate of Oman and is the language of teaching and learning in all government schools. A small number of private bilingual schools use both Arabic and English for instruction. In addition, various languages of instruction are used in international schools, which follow the educational programs of their respective countries (e.g., India, Sri Lanka, France, Pakistan, and the United States).

Mathematics Curriculum in Primary and Lower Secondary Grades

Oman has a national curriculum based on learning outcomes established by the Curriculum General Directorate.[5] Learning outcomes for each subject are determined through a system of committees, each consisting of consultants, experts, curriculum officers, assessment officers, supervisors, and experienced teachers. The Writing Committee for each subject area prepares student and teacher resources for distribution to all schools, ensuring that all students use a common set of resources (government schools and Arabic-medium private schools) to achieve learning outcomes.

The ministry also is responsible for approving the curricula of all private schools in Oman. The source of the curriculum and learning resources varies among different schools. Each curriculum must be submitted to MoE for approval, and students are required to participate in standardized testing as requested.

The Basic Education mathematics curriculum for Cycles One and Two (Grades 1–4 and 5–10, respectively) has been developed around a set of six strands: Number and Number Theory; Number Operations; Geometry, Trigonometry, and Spatial Sense; Measurement; Pre-algebra and Algebra; and Data Management and Probability.[6] All learning outcomes are correlated to a specific level of achievement in the strand for each grade level. Specific emphases within each strand include the following:

- Number and Number Theory—Emphasizes the development of number sense. Students search for and understand the many patterns and relationships among numbers. Being able to use estimation and mental calculation strategies is paramount. It is critical that students have an understanding of the concepts of whole and rational numbers. Integers, negative rational numbers, and irrational numbers are introduced in later grades. Appropriate calculator skills also are included because calculators are considered tools for studying number patterns, solving realistic problems, and eliminating tedious computations.
- Number Operations—Emphasizes the ability to perform mathematical operations with confidence with continued development of number sense. The four operations (addition, subtraction, multiplication, and division) are sequentially introduced throughout the different grade levels for each of the number systems. Specific operations are taught in an iterative manner, reinforcing concepts developed in previous grades.

- Geometry, Trigonometry, and Spatial Sense—Emphasizes the development of geometrical concepts and the cultivation of spatial awareness through the continuous integration of geometry in the curriculum. Students learn these concepts by actively manipulating, drawing, constructing, and creating geometric shapes and objects and making connections to the real world. Geometry becomes experiential and is reflected in the students' environment as an exciting and applicable aspect of mathematics.
- Measurement—Emphasizes the development of measurement sense by actively engaging students in the processes of comparing, estimating, and measuring. Measurement is regularly integrated with other subjects such as science, physical education, art, and social studies.
- Pre-algebra and Algebra—Emphasizes the presence of patterns and models in our world, linking mathematics and students' daily lives. Exploring patterns and models leads students to develop mathematical competence and gain appreciation for the beauty and power of mathematics. It is essential for students in the early grades to explore patterns in order to develop an understanding of the concept of variables and of algebraic thinking. Algebra extends the study of operations and relationships of numbers to the use of variables, and provides the ability to represent mathematical rules using symbols. Students in Grades 5–10 learn the fundamental aspects of algebra and functions. Whenever possible, practical applications of functions and graphs are studied, especially in relation to science, with emphasis on developing an understanding of basic concepts rather than on the manipulation of symbols or the extensive use of terminology.
- Data Management and Probability—Emphasizes the use of graphs, tables, and lists of numbers and statistics. Students learn to analyze data as well as develop an understanding of probability.

Science Curriculum in Primary and Lower Secondary Grades

In Basic Education science courses for Cycles One and Two (Grades 1–4 and 5–10, respectively), learning outcomes are designed to support students' acquisition of knowledge, skills, and attitudes needed for developing scientific literacy. The sets of learning outcomes and objectives include three overarching areas: Knowledge, Skills, and Attitudes.[7, 8]

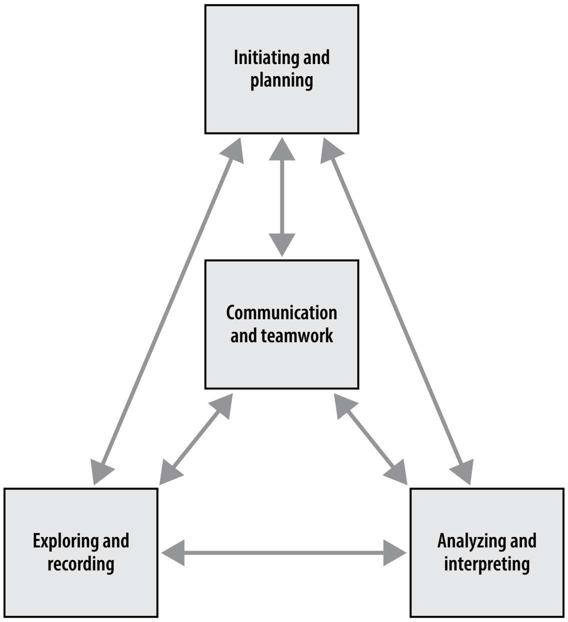
Students are expected to use Knowledge to construct understandings of the following concepts: Life Science; Physical Science; Earth and Space Science; Nature of Science; and Science, Technology, and Society. Students learn to apply this knowledge in more complex thought processes such as interpreting, analyzing, and integrating to demonstrate an understanding of the following:

- Living things and their interactions within an ecosystem;
- The structure, function, and interactions of systems of the human body;
- The structure, properties, changes, and uses of natural or human-made substances;
- The forms and transformations of energy and the need for people to use energy wisely;
- Cycles and change through the study of local and global environments and the universe;
- Scientific inquiry and the application of scientific knowledge to technological developments, and the achievements of Arabic scientists; and
- How science and technology affect, and are affected by, social and global issues.

The curriculum aims for students to develop the necessary skills for scientific and technological inquiry, for solving problems, for communicating scientific ideas and results, for working collaboratively, and for making informed decisions.

Specifically, four broad areas of skills are outlined in the framework illustrated in Exhibit 1: Initiating and Planning; Exploring and Recording; Analyzing and Interpreting; and Communication and Teamwork. The first area, Initiating and Planning, incorporates the skills of questioning, identifying problems, isolating variables, and selecting a variable for investigation. Exploring and Recording includes the skills of setting up an experiment or investigation, making observations, collecting, and recording data. Analyzing and Interpreting incorporates the skills of examining observations/data, and presenting them in an interpretable way so that conclusions can be drawn, evaluated, and the results applied. Lastly, the Communication and Teamwork area encompasses skills that are essential at every stage of idea development, testing, interpretation, debate, and consensus. The development and application of scientific ideas is a collaborative process both in the classroom and in society.

Exhibit 1: Interaction of Skills Learning Outcomes in the Science Curriculum



Each group of skills is developed in Grades 1–10, with increasing scope and complexity of application. To achieve proficiency in these skills, students are expected to

- Ask questions about objects and events in their immediate environment and develop ideas about how those questions might be answered;
- Observe and explore materials and events in their immediate environment and record the results;
- Identify patterns and order in objects and events studied;
- Work with others and share and communicate ideas about their explorations;
- Ask questions about objects and events in the local environment and develop plans to investigate those questions;
- Observe and investigate their environment and record the results;
- Interpret findings from investigations using appropriate methods;
- Work collaboratively to carry out science-related activities and communicate ideas, procedures, and results;
- Ask questions about relationships between and among observable variables, and plan investigations to address these questions;

- Conduct investigations into relationships between and among observations, and gather and record qualitative and quantitative data;
- Analyze qualitative and quantitative data, and develop and assess possible explanations; and
- Work collaboratively on problems and use appropriate language and formats to communicate ideas, procedures, and results.

Attitudes refer to generalized aspects of behavior that are modeled for students by example and reinforced by selective approval. Attitudes are not acquired in the same way as skills and knowledge. They cannot be observed at any particular moment, but are evidenced by regular, unprompted manifestations over time. It is expected that students will be encouraged to

- Recognize the role and contribution of science in their understanding of the world;
- Show interest in and curiosity about objects and events within their immediate environment;
- Willingly observe, question, and explore;
- Consider their own observations and ideas when drawing conclusions;
- Appreciate the importance of accuracy;
- Be open-minded in their explorations;
- Work with others in exploring and investigating;
- Be sensitive to the needs of other people, other living things, and the local environment;
- Show concern for their own safety and the safety of others in carrying out activities and using materials;
- Appreciate the role and contribution of science and technology in our understanding of the world;
- Appreciate that applications of science and technology can have advantages and disadvantages;
- Appreciate and respect that science has evolved from different views held by women and men from a variety of societies and cultural backgrounds;
- Show a continuing curiosity and interest in a broad scope of science related fields and issues;

- Confidently pursue further investigations and readings;
- Consider many career possibilities in science and technology-related fields;
- Consider observations and ideas from a variety of sources during investigations and before drawing conclusions;
- Value accuracy, precision, and honesty;
- Persist in seeking answers to difficult questions and solutions to difficult problems;
- Work collaboratively in carrying out investigations, as well as in generating and evaluating ideas;
- Be sensitive and responsible in maintaining a balance between the needs of humans and a sustainable environment;
- Evaluate and make determinations beyond the personal consequences of proposed actions;
- Show concern for safety in planning, carrying out, and reviewing activities; and
- Become aware of the consequences of their actions.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

The school year is 36 weeks, with approximately 32 weeks of instructional time. Individual classes generally last for 40 minutes. Students in Grades 1 and 2 have six classes in mathematics per week; students in Grades 3–8 have seven classes in mathematics per week. Students in Grades 1–3 have three science classes per week, with students in Grades 4–6 and Grades 7 and 8 having five and seven science classes per week, respectively.[9]

Instructional Materials, Equipment, and Laboratories

All instructional materials and resources are provided to schools through a central warehouse system. Student texts, workbooks, and lab manuals are written, produced, and distributed free of charge by the Ministry of Education. Multimedia resources are provided to the Learning Resource Center of each school. Schools in Cycle One (Grades 1–4) have manipulative materials and equipment in the classroom. All schools in Cycle Two (Grades 5–10) have laboratories.

Use of Technology

All Basic Education schools have a computer laboratory as well Learning Resource Center housing computers. Calculator skills are taught in the Number and Number Theory strand of the mathematics curriculum, which is designed to promote appropriate calculator use.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

In Cycle One, students receive instruction from teachers specifically prepared in combined mathematics and science instruction. In Cycle Two, students receive instruction from teachers specializing in the specific subject he or she is teaching.

Homework Policies

Oman does not have a formal homework policy, but directives from the ministry suggest that teachers should be cautious about homework and that it should not be used to determine grades. In Cycle One schools, homework is not assigned, but students often voluntarily do revision and practice exercises. In Cycle Two, homework often is used at teacher discretion, and students are expected to continue with practice and revision exercises, some individual project work, or preparation of reports and presentations. However, in Cycles One and Two, no portion of a student's grade is directly related to the completion of homework.

Teachers and Teacher Education

Teachers are prepared to work in either Cycle One or Cycle Two. All Cycle One teachers are female. Teacher education emphasizes pedagogy, with about 30 percent of the coursework devoted to specialization in English, sciences, or the humanities. Cycle Two teachers have a greater emphasis on specialization, with about 50 percent of their coursework devoted to specialization in English, sciences, or the humanities. To teach mathematics and science, teachers much have a Bachelor of Education degree with a specialization in mathematics and science.

Teacher education in Oman was previously offered at Sultan Qaboos University and six teacher colleges around the country. Beginning in 2006, five of the teacher training colleges were converted to technical colleges and teacher education programs were downsized to a single college in addition to Sultan Qaboos University, although now four private universities offer education programs. The first cohort of students attending these universities will graduate in 2011. All teacher education programs are currently four- or five-year degree programs.

Monitoring Student Progress in Mathematics and Science

Throughout the year, teachers conduct continuous assessment with quizzes, projects, participation, presentation, and oral and written work to assess learning outcomes or goals. Examinations are also used as a means of assessment and they increase in weight at the higher grades. In Cycle One, assessment is 100 percent classroom-based. In Grades 5–8, 30 percent of a student's grade is based on school-developed tests, and 70 percent is based on formative classroom assessment.[10] All examinations are developed at the school and regional level, with the exception of Grades 10 and 12. Grade 10 marks the end of the Basic Education; therefore, core exams (Mathematics, Science, Arabic Language, and English Language) are prepared by MoE and administered regionally. The Grade 12 matriculation examination marks the end of schooling. Upon passing the examination, students receive a Diploma, which is the basis of entry to the University and different colleges, and also is the means by which scholarships are awarded.

In Cycle One (Grades 1–4), students receive four report cards per year—three descriptive reports pertaining to individual achievement in each subject, including strengths and weaknesses, and a final report card. The final report card is issued at the end of the school year and shows only letter grades (A–E) for each subject. In Grades 5–8, students also receive four report cards per year, but two are descriptive (one mid-semester) and two have letter grades for each subject (one at the end of each semester).

In Cycle One, there is no grade retention except in exceptional cases. Students who receive a failing grade (E) continue to the next grade with planned remedial assistance and an individual progress plan. In Grades 5–8, a student failing one subject continues to the next grade, although students failing more than one subject may be retained. An Attainment Follow-Up Committee within the school is responsible for determining whether retention is in the best interests of the student, the class, and the school. This committee consists of the subject teacher, the head teacher, a social worker, and a parent of the child in question, who help the child at school and at home. Whether the child is retained or promoted to the next grade, the committee is required to design a special progress plan.

Impact and Use of TIMSS

The Sultanate of Oman first participated in TIMSS 2007. Among the objectives of participation was the development and improvement of the educational system. Following IEA's publication of results and international reports, two teams were formed, one for mathematics and one for science, each composed of mathematics and science curricula officers, regional supervisors, and assessment officers. The teams reviewed international reports on mathematics and science and submitted recommendations for consideration by MoE. Most of these recommendations were related to the variables included in the study instruments (questionnaires) and linking these variables to the level of attainment achieved by students who participated in TIMSS 2007.

The direct impact of TIMSS 2007 on the Omani educational system has been apparent in curriculum and assessment. In terms of curriculum, the scope and sequence of both mathematics and science were revised completely for Grades 1–10. Some learning outcomes were rearranged among the grades. New outcomes were introduced for some grade levels to align with international scope and sequence as well as local experience. Topics covered by TIMSS 2007 were also taken into consideration.

As for assessment, it was widely thought that the main reason for the low performance of students in the Sultanate of Oman in TIMSS 2007 was due to the students' unfamiliarity with the types of questions (i.e., the phrasing of questions) included in TIMSS 2007. Therefore, a main focus of teacher education in all Omani schools has been first on the mechanism of classifying questions into four cognitive levels: knowledge, understanding, application, and inference. Examples of each level were given based on items released by IEA. Second, teachers were trained to format and word questions as they are in TIMSS. Such questions are to be presented in classes on a daily basis without informing students that they are questions similar to those found on the TIMSS assessment.

Suggested Readings

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Palestinian National Authority

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Introduction

Overview of the Education System

Following the 1994 Oslo Accords, Palestinians assumed responsibility for their education system. At that time, the system of education, curriculum, teacher qualifications, and school facilities were in need of reform and updating.[1] The Ministry of Education and Higher Education has since been responsible for general and higher education in the Palestinian National Authority.

The 1998 Law of Higher Education established two frameworks for higher education:

1. Central national planning and supervision by the ministry and, after its formation in 2003, the Council for Higher Education; and
2. Self-management, self-monitoring, and self-control at the institutional level.

In particular, the Law of Higher Education gave responsibility to the Ministry of Education for accreditation and quality assurance of teacher professional development programs provided by the national universities.

In late 2007 and early 2008, the Palestinian National Authority witnessed a revival in strategic planning within all sectors and all ministries due to donor countries' renewed interest in the peace process and in providing financial support. In late 2005, before this renewed foreign interest, the ministry had undertaken an education sector diagnosis and prepared the *Education Development Strategic Plan 2008–2012*.[2] Therefore, by late 2007, the ministry was prepared to contribute to the Palestinian Reform and Development Plan, which establishes the developmental framework for sectors.

Following the creation of the *Education Development Strategic Plan*, the ministry collaborated with its local and international partners to successfully develop thematic strategies for teacher education and technical vocational education and training. Significant efforts have been made within the plan to improve the quality and enhance the relevance of education. For example, as of 2010, the student to teacher ratio in Palestinian schools was 25:1, a decrease from 38:1 in 1999.[3]

Formal education in the Palestinian National Authority is supervised by the ministry and consists of three stages: preschool education, basic and secondary school education, and tertiary education (universities and technical colleges). In addition, non-formal education, mostly related to school education, is available. In 2011, approximately 2,580,167 people were living in the West Bank, with 42 percent age 14 and under, and 1,168,858 were living in the Gaza Strip, with 48 percent age 14 and under.[4]

The preschool education (Kindergarten) stage lasts for two years, and meets the needs of children ages 4–5. Since the preschool stage is outside of formal schooling, non-governmental organizations provide most of these services. The ministry acts as a licensing agency in its supervision of this sub-sector, establishing kindergartens according to specifications for the physical facilities and setting criteria regarding the personnel who run the school and the curriculum used. According to the 2010 Global Monitoring Report, the net enrollment rate in preprimary education was 32 percent.[5]

The Basic Education Cycle in the Palestinian National Authority is compulsory for children ages 6–16 and consists of ten years of schooling (Grades 1–10). The Secondary Education Cycle (Grades 11–12) consists of two paths—academic and vocational. At the end of this cycle, students take a matriculation examination, the General Secondary School Certificate Exam, or *Tawjihi*.

In 2010, the net enrollment rate in basic education was approximately 93 percent, with equal numbers of boys and girls.[6] However, approximately 95,000 children ages 6–17 do not attend school. For those who do attend, the retention rate for Grade 5 students is 98 percent and the retention rate for Grade 10 students is approximately 82 percent.[7]

The public schools managed by the ministry represent 68 percent of all schools. Two other supervisory groups manage schools in the Palestinian National Authority: the United Nations for Relief and Work Agency manages 22 percent of the schools, and the private sector manages the remaining 10 percent of schools.

Additional programs are integrated within the formal education system, such as special education and non-formal education. Special education is offered to students with special needs. These students are included in formal education as part of an approach to "inclusive education." Non-formal education is designed for people over the age of 15 who have not participated in formal education at all or who have participated for short periods of less than four years, and who are unable to read and write well. Despite an adult literacy rate of close to 94 percent, non-formal education offers a particular focus on literacy and adult education, including pilot activities and programs in continuing education.[8]

Languages of Instruction

The languages spoken in the Palestinian National Authority are Arabic, English (which is widely understood), and Hebrew. The languages of instruction are Arabic and English.

Mathematics Curriculum in Primary and Lower Secondary Grades

The Palestinian curriculum[9] is built upon a spiral approach; main concepts are introduced and then expanded throughout consecutive grades. Grades 1–12 have a formal and centralized curriculum and a grade structure that is divided into three stages:

1. Preparatory Stage (Grades 1–4);
2. Empowerment Stage (Grades 5–10); and
3. Take-off Stage (Grades 11–12).

The main content domains in mathematics are Number, Operations, Measurement, Geometry, Statistics, Probability, and Algebra. The main objectives for teaching mathematics in Grades 1–8 include the following:

- Develop skills with numbers, including the decimal system and arithmetic operations;
- Develop number sense and estimation ability;
- Develop an understanding of basic geometric shapes, their properties, and relationships;
- Develop skills with data and probability;
- Develop problem-solving abilities;
- Develop mathematical skills applied to technology and science;
- Develop mathematical skills applied to real life situations; and
- Acquire positive attitudes toward mathematics.

The guidelines for teaching mathematics domains in Grade 4 are as follows:

- Number and Operations—Numbers up to 7 digits; representations of numbers, including the use of an abacus, number lines, and charts; comparison and ordering of numbers; the four basic operations (addition, subtraction, multiplication, and division); estimation; even, odd, prime, and composite numbers; fractions and decimals; and basic number theory.
- Geometry and Measurement—Units of length, time, area, mass, and volume; angles; and perpendicular and parallel lines.
- Statistics and Probability—Tables; pictographs; and random experiments.

The guidelines for teaching mathematics domains in Grade 8 are as follows:

- Number and Operations—Natural numbers, integers, rational numbers (including fractions, improper fractions, decimals, and percentages), and real numbers (including irrational numbers and roots); and problem solving using the four basic arithmetic operations.
- Geometry—Two-dimensional shapes (e.g., triangles, quadrilaterals, and polygons) and three-dimensional solids (e.g., cubes, polyhedrons, and cones); congruence and similarity; the Pythagorean Theorem; and formulas for finding perimeter, surface area, and volume.
- Statistics and Probability—Pie charts, and bar and line graphs; random experiments; and probability laws and applications.
- Algebra—Variables, open sentences, equations, and inequalities with one variable; linear equations with two variables; and problem solving.
- Trigonometry—Basic trigonometric ratios (sine, cosine, and tangent); right triangles; tables of trigonometric ratios; and real-world applications (angles of elevation and depression).
- Financial Mathematics—Financial profiles of companies; bonds; and insurance.

Science Curriculum in Primary and Lower Secondary Grades

The Science Curriculum in the Palestinian education system introduces science for Grades 1–10 as a general subject. In Grades 11 and 12, students learn the separate branches of science, specifically physics, chemistry, biology, and earth science as separate subjects. The main objectives for teaching general science in Grades 1–8 include the following:

- Develop skills such as observation, classification, communication, measurement, experimentation, and inductive and deductive reasoning;
- Encourage logical thinking;
- Develop problem-solving skills;
- Encourage curiosity and perseverance;
- Encourage good health habits;
- Develop mathematical skills applied to science;
- Develop computer and technology skills related to science;
- Develop positive attitudes towards science; and
- Develop a sense of responsibility toward the environment and society.

The main themes of the science curricula in primary and lower secondary education are as follows: human anatomy; plants; animals; matter and energy; environment; earth and universe; the atmosphere; meteorology; communication, science technology, and society; microorganisms; cell theory; motion, light, and vision; and magnets.

The guidelines for teaching science in Grade 4 outline the following topics:

- The Human Body—The digestive system and nutrition, and the respiratory system;
- Electricity and Magnetism—Electricity in our lives, electric circuits, and magnets;
- Sound—Music and noise; the production and properties of sound, and hearing;
- Weather—Temperature, clouds, and precipitation;
- Ecosystems—Humans and the environment, and food chains;
- Light—Sources and behavior of light, lenses, the eye, and vision;
- Classification of Animals—Vertebrates and invertebrates;
- The Earth and the Solar System—Planets and stars, and movement of the Earth and the moon; and
- Communication and Information—Cell phones, computers, and the Internet.

The guidelines for teaching science in Grade 8 outline the following topics:

- Cells—Cell components, cell division, and microscopes;
- Classification—The plant and animal kingdoms, and microorganisms;
- Atoms—Elements and the periodic table;
- Chemical Reactions—Chemical equations, compounds, and solutions;
- Geology and Earth History—Structures in sedimentary rocks, and fossils;
- Atmosphere—Climate;
- Wave Motion and Sound;
- Light and Optics—Reflection and refraction; and
- The Solar System—Asteroids, comets, and meteors and meteorites.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Science teacher curriculum guides for Grades 1–6 and mathematics teacher curriculum guides for Grades 1–4 include teaching instructions and enrichment learning materials for teachers. The basic teaching and learning strategies introduced in these guides are as follows:

- Exposition Strategies—Explanation; lecture; demonstrations; films; pictures; shapes; and education by radio, narrative, and stories;
- Interaction Strategies—Discussion, analysis and reasoning, seminars, and deductive method; and
- Exploration and Experiential Strategies—Direct experience, survey, conducting research, inductive method, self-directed learning, testing, cooperative learning, case study, and role-playing.

These methods and strategies are dominant in the teaching of mathematics and science in the Palestinian National Authority schools. The lower stage of basic education focuses on cooperative learning, use of drama, role playing, learning through play, use of narrative method, child-centered learning, and a focus on applications, each of which help the learner integrate concepts into his or her cognitive structure in the form of patterns. At the upper stage of basic education and in secondary education, other methods are used: discussion, problem solving, experimentation, exploration, scientific deduction, inductive thinking, modeling, scientific inquiry, and the employment of ICT.

The school week for students in Grades 1–4 totals 27 teaching periods for all subjects. In public schools, each period is 40 minutes long; in private schools and schools operated by the United Nations for Relief and Work Agency, each period lasts 45 minutes. Students in Grades 5–10 have 25 periods of instruction per week, and students in Grades 11–12 have 22 periods of instruction per week. For students in Grade 4 and Grade 8, mathematics and science are taught five and four periods per week, respectively.

Instructional Materials, Equipment, and Laboratories

The Ministry of Education and Higher Education's formal regulations require a resource room in each school serving Grades 1–4, a general science laboratory in each school serving Grades 5–10, and specialized science laboratories in each school serving Grades 11–12. In general, 62 percent of schools are equipped with at least one science laboratory and 69 percent are equipped with a computer laboratory. TVs, VCRs, DVD players, and overhead projectors are commonly available in schools.[10]

Use of Technology

Computer software is used for data manipulation (e.g., Excel) and for content demonstration (e.g., PowerPoint). The Internet is used as a source of information. Some teachers require computer use, but the Palestinian National Authority has no obligatory policy in this regard.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Students have specialist teachers for mathematics and science starting at Grade 5, and occasionally in Grades 1–4.

Homework Policies

The ministry does not have a formal regulation requiring teachers to give homework in terms of frequency or quantity. However, the teacher guide for mathematics at the fourth grade specifies that teachers give students a worksheet at the end of each unit as homework.

Teachers and Teacher Education

The Ministry of Education and Higher Education considers selecting and educating teachers (both pre- and in-service education) as one of the most influential factors in education. In early 2007, the ministry instituted a process of developing a national *Teacher Education Strategy in Palestine*, whose general objective was to "develop sufficient and efficient teachers in order to improve the learning opportunities for all Palestinian students in all schools." [11] The specific objectives of this strategy include developing the following:

- Teacher education programs and the higher education institutions that provide them;
- Programs of in-service education and of continuing professional development;
- The structure of the teaching profession, to encourage effective teachers to join and remain in the profession; and
- The management of the teacher education system.

According to the *Teacher Education Strategy*, the required educational levels for "qualified teachers" are as follows:

- Lower Basic Education Teachers (Grades 1–4)—A bachelor's degree in education;
- Upper Basic Education Teachers (Grades 5–10)—Either a bachelor's degree either in education or in a subject from the School of Arts and Sciences at a college or university and an Educational Diploma; and
- Secondary School Teachers (Grades 11 and 12)—A bachelor's degree in a subject from the School of Arts and Sciences at a college or university and an Educational Diploma.

These criteria also have been modified and applied to current teachers. In-service teachers are considered qualified if they hold a bachelor's degree (or higher) that includes education as a minor subject or as a subject of a pre-bachelor's diploma. Teachers with a master's degree or doctor of philosophy in education also are considered qualified. Furthermore, teachers should only teach in the subject area and in the educational stages for which they were qualified.

According to the ministry, based on these criteria, about 70 percent of in-service teachers are not "educationally qualified"; thus, the ministry has been working to qualify them since early 2011.[12] For teachers of mathematics and science, qualification efforts have focused on helping those holding Bachelor of Science degrees in mathematics and science to earn a master's degree in education or an education diploma. For mathematics and science teachers holding only an education diploma, a plan was discussed with the national universities to upgrade this credential to a bachelor's degree in teaching mathematics and science.

Parallel to these efforts, the ministry has developed a set of 24 national professional teacher's standards for all Palestinian teachers.[13] Two of these standards pertain to the importance of depth-of-knowledge for teachers of mathematics and science, and the use of information and communications technologies for all teachers. By the 2014–15 school year, the ministry is committed to hiring only teachers qualified according to the *Teacher Education Strategy* criteria.

Requirements for Ongoing Professional Development

The Ministry of Education and Higher Education has adopted a teacher supervision system with the aim of supporting teacher development rather than inspection. In 2007, two new roles for supervisors were established:

1. Resident Supervisor—Responsible for supervising, evaluating and supporting teachers and principals who are located in a cluster of 3–5 schools; and
2. Friend Supervisor or Specialization Supervisor—Works with individual teachers to improve pedagogical practices in specific subjects.

In 2008, a new "comprehensive monitoring" supervision program was introduced primarily to assess and improve each element of the educational system.[14] The program accomplishes these goals through interviewing students and principals, observing school environments, monitoring student achievement and relating it to teaching, and conducting discussion sessions with teachers and parents related to student achievement in an attempt to develop remedial plans, pedagogies, and evaluation strategies.

Supervisors conduct in-service training for teachers in the following five thematic areas: inquiry-based teaching, experiential-based teaching, using science kits, preparing laboratory manuals for students in Grades 5–10, and teaching laboratory science. According to the ministry, 100 percent of teachers have received in-service training.[15]

Monitoring Student Progress in Mathematics and Science

Beginning at Grade 4, teachers are required to conduct four in-class exams during the school year. Each student receives two report cards annually: one at the end of the first semester, and the second at the end of the academic year.

The Ministry of Education and Higher Education conducts national assessments in Arabic language, Mathematics, and Science at Grades 4 and 10. The national assessments are implemented in a two-year cycle and are sample-based to provide qualitative and quantitative indicators to help evaluate educational outcomes and develop policy studies and intervention programs.

The ministry also conducts a unified test in Arabic language, mathematics, English language, and science for Grades 4, 5, 7, 8, and 9 at the end of each semester. The tests survey West Bank schools to develop educational policies and evaluate teaching activities.

At the secondary stage, students choose an education stream based on their achievement. A student who scores a minimum of 60 percent in mathematics and science in tenth grade may choose the scientific stream. Students who do not achieve this score may choose literary or vocational streams.

Students in Grades 1–3 progress through each grade with their age cohort. Even if children are not achieving well, ministry policy does not require retention at that level. However, from Grades 4–12, ministry regulations allow students to repeat a grade if they fail in four or more subjects.

Impact and Use of TIMSS

TIMSS results have been one of the major instruments for educational policy development and decision making in the Palestinian National Authority. During the evaluation of the education system conducted in 2005, TIMSS 2003 findings were used to highlight major challenges to be addressed in the *Education Development Strategic Plan*. Indeed, TIMSS results are recognized as one of the 23 major indicators guiding the implementation of the plan.

TIMSS results and related indicators also are integrated within the monitoring and evaluation system in the Ministry of Education and Higher Education to improve quality. For example, a detailed analysis of TIMSS data and results was used by educators and researchers to further analyze the education system, and to direct decision making by exploring those factors that explain variation in TIMSS results. TIMSS released items also have been disseminated to all schools to be used as models by mathematics and science teachers in their teaching and testing activities.

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Poland

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Introduction

Overview of the Education System

Since 1989, the Polish education system, much like the country's government, has gradually become decentralized. Between 1991 and 1999, local governments, which receive subsidized funding from the state, became responsible for the provision of education.

Education is presently regulated by several parliamentary acts and Ministry of National Education ordinances. Within the broad limits delineated by official documents, there is much room for other agents, such as educational publishers, test makers, school principals, and teachers, to jointly decide the conditions of students' educational experiences.

The Polish education system consists of four levels: preprimary (*Przedszkola*, or Grade 0), primary (*Klasy 1–6,* or Grades 1–6), lower secondary (*Klasy 1–3,* or Grades 7–9), upper secondary (*Klasy 1–3 lub 4*, or Grades 10–12 or 13), and postsecondary (1–3 semesters). Preprimary education is available for children beginning at age three and participation is voluntary and decided by parents. However, all six-year-old children must attend Grade 0 prior to beginning primary school.

Primary school consists of two periods: integrated teaching (Grades 1–3), and teaching subjects (Grades 4–6). In the integrated teaching period, one teacher covers most of the content across all subjects and assesses student achievement descriptively. The TIMSS 2011 assessment was administered to students in Grade 3, which is the final grade of this period, the fourth year of compulsory education, and was attended by children ten years of age, on average, at the time of testing. In the subject teaching period, students have separate teachers for the major subject areas (Polish, history and society, mathematics, science, arts, physical education, and religion) and students are assessed using grades.

The lower secondary level (*gimnazjum*) enrolls all students who graduated from primary school and does not employ tracking. In the last grade of lower secondary (Grade 9), students take a battery of five or six external examinations.

The upper secondary level comprises three types of schools: general education (*liceum*), general vocational (*liceum profilowane*), and vocational (*technikum*). Each type of school offers a final external examination (*matura*), which entitles students with passing scores to apply to an institution of higher education. Typically, general education graduates achieve the highest examination test results of all upper secondary school students, thereby earning a greater chance than others to study at prestigious universities. The postsecondary level is available to upper secondary school graduates who wish to gain vocational qualifications for a trade or occupation.

Two- or three-year basic vocational schools, which prepare students for skilled industrial or trade vocations, are exceptions to the structure of Poland's education system. About 20 percent of lower secondary school graduates attend these schools. Upon completion, students receive a certificate that may not be used for entry into institutions of higher education.

Languages of Instruction

Polish, the official language of Poland, belongs to the Western Slavic group of Indo-European languages. German, Ukrainian, Belarusian, and Kashubian are among the languages spoken by national and ethnic minorities in Poland. Polish is the language of instruction in all schools. Children from national and ethnic minorities (1.6% of primary school students) also attend mother-tongue-and-culture classes.[1]

The Polish Curriculum in Primary and Secondary Schools

The 1999 National Curriculum (*Podstawa programowa*) forms the basis of instruction in all schools.[2] The curriculum divides education into four 3-year periods and describes expectations for each subject area within each period (with the exception of the first). That is, for each subject, the National Curriculum specifies the teaching objectives, school responsibilities, educational content, and expected learning outcomes. Every teacher is obliged to incorporate the National Curriculum into their own grade-specific curriculum or to choose one of the commercial curricula approved by the Ministry of National Education.

A new National Curriculum is currently being implemented in Poland, beginning with the cohort of students that entered Grade 0 in the 2009–10 academic year.[3] However, because the new curriculum did not apply to the students tested in TIMSS 2011, the 1999 National Curriculum is described.

Mathematics Curriculum in Primary and Lower Secondary Grades

According to the 1999 National Curriculum, mathematics is a mandatory subject area at all education levels and in all types of schools. The objective for teaching mathematics in Grades 0–3 is encapsulated by a single statement in the National Curriculum: "enabling students to perform basic arithmetic operations." [4] Mathematics instruction at this level includes the following content:

- Spatial relations, ordering, and classification;
- Counting (counting objects, independence of the number of objects from the counting method, comparing sizes of sets);
- Number notation up to 10,000, including decimal notation;
- Arithmetic operations (addition, subtraction, multiplication, and division; algorithms of addition, subtraction, and multiplication by one-digit numbers), and order of operations;
- Measuring, weighing, counting money, and using the calendar;
- Describing concrete situations with mathematics, solving one-operation and simple multiple-operation word problems; and
- Geometric figures, including triangles, squares, rectangles, and circles.

At the lower secondary level (Grades 7–9), mathematics is seen as a tool to solve problems encountered both in different academic subjects and everyday life. Teaching mathematics also is deemed necessary for the development of spatial awareness. Mathematics instruction at this level includes the following content:

- Rational numbers, percentages, and whole number exponents and roots;
- Decimal approximations and examples of irrational numbers;
- Algebraic expressions, including notation and calculation, and short multiplication formulas;
- Examples of functions, and recognizing and determining properties of functions from graphs;
- Linear equations and inequalities in one unknown, systems of linear equations in two unknowns and their geometric interpretation;
- Collecting, processing, and presenting data;
- Simple random events;

- Polygons, circles, bisectors, central and inscribed angles, triangle congruence, and inscribed and circumscribed triangles;
- Examples of geometric transformations;
- Polygon and circle circumference and area;
- Relationships between sides and angles in figures, the Pythagorean theorem, and similar figures; and
- Perpendicularity and parallelism in space, prisms, pyramids, solids of revolution (cylinder, cone, sphere), and calculating areas and volumes of these figures.

Science Curriculum in Primary and Lower Secondary Grades

The 1999 National Curriculum reduces the goal of science instruction in Grades 0–3 to "the awakening of the need to be in touch with nature." [5] Science instruction at this level includes the following content:

- Nature in the immediate surroundings;
- Observing and reporting natural phenomena and processes;
- Preserving nature in the immediate surroundings;
- Knowledge about one's body;
- Health care, personal hygiene;
- Nutrition; and
- Safe use of common technical appliances.

In lower secondary (Grades 7–9), science is divided into four subjects: geography, biology, chemistry, and physics with astronomy. The 1999 National Curriculum describes each subject separately because the main goal of lower secondary education is "to introduce students into the world of scientific knowledge by acquainting them with the language, concepts, laws, and methods specific for the selected disciplines, to the extent necessary for further education." [6] The curriculum describes the content and expected student achievement for each subject generally. For example, the curriculum describes the content of biology with only eight themes:

- Organisms—Structures (e.g., cells, tissues, organs) and functions;
- Examples of natural adaptation to the environment;

- Human Body Systems—Structures and functions;
- Health and Disease—Examples of contagious diseases and pathologies in organ function; and basics of epidemiology, and prevention and treatment;
- Biological and psychological stages of human development and needs associated with each stage;
- Genetic information; and hereditary and environmental influences affecting characteristics of organisms;
- Within- and between-species relations; matter and energy flow in various ecosystems; and
- Effects of human activity on the environment.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

In Grades 0–3, no specific amount of time is prescribed for mathematics or science instruction because teaching in these grades is integrated (i.e., not divided into separate subjects). Most curricula prescribe no more than one-tenth of the total instructional time for science. For lower secondary grades, the total mathematics instructional time is 420 contact hours and the total science instructional time is 140 contact hours for each of the four subjects taught—geography, biology, chemistry, and physics with astronomy.

In all grades, teachers determine methods of instruction. The manuals, which are often part of the commercial sets of educational materials in use, describe instructional strategies for mathematics and science classes. The main difference between teachers' instructional strategies is in the way they use textbooks in class. In mathematic classes, some teachers routinely ask students to complete the exercises prescribed by the textbook, individually or in small groups, while other teachers engage students in educational games, experiments, and problem-solving activities, using textbooks only to reinforce material. Recent PISA results suggest that problem-solving skills are not emphasized in mathematics instruction; while Polish students surpass the Organisation for Economic Cooperation and Development (OECD) average in routine mathematics tasks, they score below average in reasoning (e.g., whether an algorithm is applicable in a given situation).[7]

Instruction in elementary science classes is similarly dichotomous. For example, either students examine pictures of wildlife in textbooks and listen to teachers' comments, or students go to a park, meadow, or the woods to observe plant and animal life. Science passages appear frequently in textbooks for Polish language instruction and it is quite common for authors to insert science-related topics into language instruction materials. For example, during a lesson on Copernicus, a teacher may introduce the notion of the solar system and describe the sun and planets, although these topics are not mentioned in the 1999 National Curriculum. Many teachers believe the National Curriculum and commercially published curricula are too narrow in scope and therefore try to enrich science instruction with additional topics which may be attractive to students.

At the lower secondary level (Grades 7–9), mathematics is usually taught through watch-and-repeat methods. After a short introduction of a new concept or algorithm, a teacher solves a typical problem on the blackboard. Students copy the solution and do many similar exercises, individually or in small groups. More exercises are given for homework. At least twice a month students take a short quiz covering the recently taught material.

Science instruction in lower secondary grades is determined by geography, biology, chemistry, and physics textbooks. A typical biology textbook operationalizes the 1999 National Curriculum in the following way:

- Grade 7 (*Klasa 1*)—Varieties of organisms (how organisms function, from viruses to algae, and the world of plants);
- Grade 8 (*Klasa 2*)—Humans and their surroundings (the world of animals, the human body, integration of human body functions, and principles of taking care of oneself); and
- Grade 9 (*Klasa 3*)—How humans change nature (biology closest to the essence of life, ecology, and evolution).

Textbooks are standard instructional materials in almost all schools and must conform to the National Curriculum. Several textbooks for each subject are commercially available and compete for teacher use. In a typical textbook, terms, facts, and laws are more prevalent than practice problems. Survey data indicates that students see their textbooks as a necessary evil and would like to get rid of them entirely, although students admit textbooks are useful when preparing for quizzes and tests.[8]

Teacher lectures dominate science classes, usually supported by large-scale maps, tables, pictures, or short films, and students have little time to pose their own questions. Classroom demonstrations or field trips are rare and scientific experimentation is even rarer. It is estimated that in about half of the classrooms, scientific experiments are carried out once or twice a year at best. Moreover, most experiments are scripted inquiry exercises that involve following a ready-made scenario under the teacher's guidance. Teachers attribute the minimal use of experiments to a lack of equipment and substances and to the rigid 45-minute class structure, which is too short to carry out many types of experiments.

The results from PISA 2009 indicate student science achievement in Poland had improved since 2006 and was significantly higher than the OECD average. No improvement, however, was observed in the 13 test items measuring recognition of scientific problems. Moreover, there was a decline in performance on items that required posing a research question and selecting evidence to support a hypothesis.[9]

Instructional Materials, Equipment, and Laboratories

Instructional resources vary widely among schools, depending on local government resources and school policy. Teachers employ manipulatives to teach mathematics in primary grades, including colorful rods (Cuisenaire rods), Dienes blocks, Numicon Kits, abaci, dice, and sets of polygons. Monetary calculations are carried out with oversized models of coins and banknotes, and measurement lessons involve the use of scales, clocks, and measuring cups and tapes.

The equipment used in science instruction largely depends on teacher ingenuity. In science classes, students typically may do the following: systematically observe and record weather conditions on the basis of thermometer and anemometer readings; learn about the points on the compass; play thematic board games; and study large-scale maps, drawings, and photographs.

Most lower secondary schools have one or more separate science rooms. In Warsaw, 80 percent of schools have a physics laboratory with basic equipment for demonstrations and experiments, such as scales (67%), dynamometers (83%), and lenses and prisms (63%). Biology laboratories contain microscopes, permanent microscopic sections, and specimens.[10] Outside the main cities, laboratories are rarer and are often used for teaching more than one subject. In general, however, school laboratories are seldom true scientific laboratories in which students may conduct their own experiments. Especially during chemistry classes, teachers restrict themselves to providing demonstrations because of the high cost of laboratory glass and substances.

Use of Technology

Most classrooms in Polish primary schools have audiovisual equipment available. For example, many educational films and records with wildlife sounds are available for science instruction. However, few computers are available to children in Grades 0–3. In primary schools, there is one computer for every ten students, on average.[11] Computer rooms are used primarily by students in Grades 4–6 during information technology classes. In lower secondary schools there is one computer for every eight students, on average.[12] While many computer programs are available for mathematics instruction, there are very few programs for science instruction. Many schools have one or two interactive whiteboards which may be used for some classes, but schools with an interactive whiteboard in every classroom are rare. Most science laboratories are equipped with a computer and a multi-media projector at the teacher's desk; some also have an interactive whiteboard.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

In Grades 1–3, students do not have specialist teachers for mathematics or science. In lower secondary grades, mathematics, geography, biology, chemistry, and physics are taught by specialist teachers.

Homework Policies

The main goal of homework is to help students memorize the content taught in class. The quality of homework provides the teacher with information about whether students understood the content and allows the teacher to make formative decisions about whether to review the main instructional points or provide additional exercises in the next class. Homework also is believed to create independent orderly study habits and conscientious attitudes.

In primary grades, mathematics homework is assigned to students daily. It consists of simple arithmetic drills, word problems, drawing geometric shapes, and measuring the length of lines. Science homework is rarer and usually involves completing a small project, such as planting beans and making notes about how they grow.

In lower secondary grades, homework is given in almost every class. Mathematics homework usually consists of exercises similar to those done in class. Science homework may involve reading the textbook and memorizing content, although more and more frequently teachers are requiring students to search for specific information on the Internet or in popular science periodicals and books.

Teachers and Teacher Education

Teacher Education Specific to Mathematics and Science

Every teacher must successfully complete a university or college course of study comprising a three-year bachelor's (first) and a two-year master's (second) degree, in addition to a one-year practicum in a school. A lower primary school teacher must have a degree in elementary education. A lower secondary school teacher must have a degree in the subject taught.

Requirements for Ongoing Professional Development

Polish teachers have ample opportunities for professional development. Universities offer postgraduate courses for teachers wanting to qualify to teach additional subjects, and every province has a public in-service education center. Commercial educational firms also offer shorter or longer courses. These include, for example, "I multiply and divide: educational games for elementary grades," "Logic games in mathematics teaching," and "Birds in elementary education." Attendance in professional development courses counts towards promotion, though teachers are not obligated to attend.

Monitoring Student Progress in Mathematics and Science

Primary grade teachers are required by law to assess every student's achievement twice a year. The assessment is descriptive in nature and specifies the student's academic and social achievements, as well as his or her strengths and weaknesses. The law does not permit the use of conventional grades.

During the academic year, a teacher collects information on student achievement in the form that he or she finds appropriate, such as with conventional grades (1 being the lowest, 6 the highest) or through other forms devised by the teacher, including short comments or student portfolios.

Students in Grades 0–3 do not take national examinations. Commercial achievement tests available on the educational market compete for teacher use and usually consist of a few items that assess students' understanding of short, informative texts and knowledge of basic facts.

Students take their first external examination in the final grade of primary school (Grade 6, age 13) and the second at the end of lower secondary school (Grade 9, age 16). The first examination requires a student to complete a single standardized paper-and-pencil test within 60 minutes. Approximately half of the test items assess mathematics and science. The second examination comprises two standardized tests: one in the humanities, and the other in mathematics and science. Each test takes two hours to complete. The two examinations provide information about student achievement, but graduation is not contingent upon the examination score. The importance of the examinations grows, however, if the number of applicants to the next educational level (upper secondary) exceeds the number of available positions. In such circumstances, a typical admission policy is to select applicants based on examination scores.

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Portugal

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Introduction

Overview of the Education System[1, 2]

Education is guaranteed to all citizens in Portugal, and the Portuguese education system provides access to continuous learning and promotes the development of individual personality, social progress, and a more democratic society.

In Portugal, public education is non-denominational. The national government is responsible for ensuring democracy in education, and as such may not govern education and culture based on any particular philosophical, aesthetic, political, or religious principles. The government also safeguards the right to establish private or cooperative schools; authorities from the Ministry of Education conduct administrative and financial inspections of these schools, and specific laws in the Education Act (1986) regulate and determine their status.[3, 4]

The Ministry of Education determines the curriculum at the national level. The ministry also defines teaching method guidelines, which are adapted by teachers to align with each school's education plan. The national government finances public schools in addition to supporting those private schools and institutions associated with the Ministry of Education in areas where there are public school shortages. Schools conduct student assessment, and students must take final examination as in public schools. The curriculum is determined at the national level.

In 1986, the Education Act established nine years of compulsory schooling (Grades 1–9, or up to age 15). In 2009, compulsory education was extended to twelve years of schooling (or up to age 18).

Public preprimary education is for children ages 3–5 and can be provided in facilities where one or more levels of compulsory education are taught or in separate nursery schools. Classes are formed based on pedagogical criteria and depend on the methods and principles defined by each school's pedagogical council; schools must organize these classes according to age whenever the school structure permits. Nursery school teachers are responsible for curriculum development, which must take into account the general goals of preprimary education—the organization of the educational environment, curriculum targets, and content areas (personal and social education, expression and communication, knowledge of the world). Preprimary education is not compulsory, but about 99 percent of five-year-olds attend.

Basic education (*ensino básico*) includes three cycles: first cycle, lasting four years (Grades 1–4); second cycle, lasting two years (Grades 5–6); and third cycle, lasting three years (Grades 7–9). Children progressively move from one cycle to another, completing and adding knowledge learned in each previous cycle. Children are admitted to basic education if they reach the age of six before September 15th or, if requested by the child's legal guardian, between September 16th and December 31st.

In the first cycle of basic education (Grades 1–4), teaching is the responsibility of a generalist teacher who may receive assistance from other teachers in specialist areas (e.g., music, foreign language, and physical education). The second cycle of basic education (Grades 5–6) is organized into multidisciplinary areas of study, each ideally having one or two, semi-specialist teachers. The study plan for this cycle includes the following curriculum subject areas:

- Languages and Social Studies—Portuguese language, foreign language (French, German or English), history, and geography of Portugal;
- Mathematics and Sciences—Mathematics and natural sciences;
- Artistic and Technological Education—Visual and technological education, music, and physical education; and
- Personal and Social Education—Religious and moral Education (optional).

Other non-subject-specific curriculum areas include projects, directed studies, and civics. Education for citizenship is cross-curricular. Compulsory foreign language learning also begins in the second cycle, with the aim of giving students command of a language in a structured and sequential way.

In the third cycle of basic education (Grades 7–9), teaching is organized into multidisciplinary areas of study taught by specialist teachers. The curriculum in this cycle includes the following subject areas: Portuguese language, foreign language, human and social sciences, mathematics, physical and natural sciences, visual arts, an elective subject (e.g., music, theatre, or dance), technological education, physical education, introduction to ICT

(Grade 9), personal and social education, and religious and moral education (optional). Learning a second foreign language is compulsory in this cycle, and students can choose from French, English, German, and Spanish. The non-subject-based curriculum areas in the third cycle also include projects, directed studies, and civics.

In upper secondary education (Grades 10–12), each school provides courses from a list of courses proposed nationally. Schools may choose appropriate courses based on local or regional socioeconomic conditions, or based on the types of qualifications needed in the work force. General upper secondary education is structured around differentiated tracks comprising two branches: courses geared primarily toward the pursuit of further education, and courses geared toward working life. Students may change from one branch or course of study to another. All general education courses have a common education component that includes Portuguese language, foreign language, philosophy, and physical education.

In the scope of the Global Strategy for the National Curriculum Development, the Ministry of Education has defined learning goals (*Metas de Aprendizagem*) as a tool to support curriculum management by teachers and schools, and to inform students and families of expected student achievement in each cycle of education.[5]

Emphasis on Mathematics and Science

A set of measures has been developed to improve teaching and learning conditions in the first cycle of compulsory education, and to promote the effective integration of the first four years of schooling. Some of these measures involve mathematics, science, and Portuguese language, such as the following:

- Programs for in-service training for teachers of mathematics, Portuguese language, and experimental science; and
- The definition of curriculum orientations and the establishment of minimum hours dedicated to teaching core curriculum subject areas.

Other measures relevant to these subjects are in development for all cycles of basic education. Measures include increasing the number of teaching hours per week, improving teacher education, and implementing a national plan for reading. This national plan seeks to involve schools, families, and local libraries in promoting reading and is primarily aimed at students in Grades 1–9, though there are efforts to include Grades 10–12 as well.

Languages of Instruction

Portuguese is the language of instruction in all public schools. In some private schools that do not use the Portuguese curriculum, the language of instruction is not Portuguese. In 2008–09, one-third (3,590,585) of Portugal's total population comprised young people under the age of 30, and 32 percent of this age group (1,155,757) were enrolled in compulsory education.[6]

Mathematics Curriculum in Primary Grades

The mathematics curriculum is divided into cycles and includes general educational targets, planning instruction and teaching methods, subject matters and competencies, and general assessment guidelines for all basic education (Grades 1–9).[7] The following describes some characteristics of the first cycle curriculum for TIMSS 2011 students.

The content of the first cycle curriculum has three mathematical domains: Numbers and Operations, Geometry and Measurement, and Working with Data. General guidelines emphasize the importance of problem solving, mathematical reasoning, and communication in exploring all first cycle curriculum domains. Learning targets are combined for Grades 1–2, and Grades 3–4, and Exhibit 1 presents the concepts and content that students are expected to learn in both grade ranges.

Exhibit 1: Mathematics Concepts and Content, Grades 1–2 and 3–4

Grades 1–2	Grades 3–4
Domain: Numbers and Operations	
Develop basic mathematical abilities and understand and use numbers up to 1,000; Learn the concepts underlying the four arithmetic operations (addition, subtraction, multiplication, and division), and appropriately use these operations to solve real-life problems; and Gain an introduction to fractions.	Continue to develop understanding of numbers to 1,000,000; and Use arithmetic operations and become familiar with different forms of number representation (i.e., decimals, percentages, and fractions).
Domain: Geometry and Measurement	
Observe, order, and structure spatial relationships and shapes; develop orientation ability; and describe simple geometric figures; and Estimate quantities in different contexts and learn to compare and formulate relationships using different measurement units, such as length, time, weight, and currency.	Identify and classify geometric figures, measure objects, and calculate, perimeter, and area of rectangles and squares; and Hone estimation abilities and focus on measuring, comparing, and transforming units of measurement.
Domain: Working with Data	
Learn to read and interpret data presented in tables and graphs, and to classify data using Venn and Carroll diagrams.	Expand abilities to read, interpret, and represent data, while also identifying modes and probabilities in data sets.

Science Curriculum in Primary Grades

In the first cycle of basic education (Grades 1–4), science is part of a core subject that involves students understanding the social and natural environment in which they live. The curriculum, therefore, comprises six thematic clusters that allow teachers to explore social and natural sciences with their students: Discovering Myself, Others and Institutions, the Natural Environment, Places, Materials and Objects, and Relations between Nature and Society. The following describes how science is included in the first cycle curriculum for TIMSS 2011 students.

The curriculum provides teachers general methodological orientations for each thematic cluster and a description of content by grade within each cluster. For science, the curriculum contains several recommendations about experimental work that cross all grades. Specifically, students should have learning opportunities that aim to develop the following skills: collecting data; designing simple experiments related to concepts and rules of physics, biology, and chemistry; observing; classifying; and reporting.

In the Natural Environment cluster in Grade 1, students observe characteristics of living organisms (animals and plants) and their habitats, and distinguish and record atmospheric conditions. Throughout Grades 2–3, student observation of plants and animals expands to include different kinds of plants and different categories of animals, including their habitats and ways of life. Students should be able to classify plants and animals according to characteristics (e.g., appearance, what they eat, reproduction, and habitat). Students in Grades 2–4 also learn about weather and climate—first with regard to seasons and climate changes, and later discussing weather and climate influences in animal life and plant growth. By Grades 3 and 4, students begin to develop their awareness of other dimensions of the natural environment, such as soil characteristics, rocks, mountains and valleys, rivers and oceans, and astronomy.

In the Materials and Objects cluster, beginning in Grade 1, students explore the characteristics of several materials (e.g., water, wood, rubber, sand, sugar, and salt) and group them by their properties. By Grade 2, teachers introduce air; by Grade 3, light (optics) and forces (statics and dynamics); and by Grade 4, electricity and sound.

Students explore real-life experiences at all grades.

Instruction for Mathematics and Science in Primary Grades

Primary school teachers (Grades 1–4) are generalists who teach all subjects of the primary school curriculum (i.e., they teach mathematics, science, and all other subjects). In Grades 5–12, teachers are able to teach one or more subjects, depending on their qualifications.

The total amount of instructional time in first cycle is 25 hours per week, as prescribed by the national curriculum. Of this total time, eight hours are intended for Portuguese language, seven hours for mathematics, five hours for arts, and five hours for social and natural science subjects. Of the prescribed five hours for science, half of the time is intended for experiments and research activities.[8] At all school levels, it is recommended that student work in science involve experimental and research activities suited to the nature of the different areas or subjects.

Because many schools are organized in clusters that include all levels of education (i.e., from preprimary to upper secondary), teachers from different levels can cooperate to implement the national curriculum for mathematics and science in Grades 1–12.

Instructional Materials, Equipment, and Laboratories

Teachers are free to choose their own instructional materials and generally work with other teachers in the same cycle teaching department to prepare lessons and agree on curriculum management. The curriculum includes example lesson suggestions, lists of books, and non-compulsory materials. A ministry committee approves textbooks, verifying adherence to the national curriculum; teachers then choose those textbooks that best suit their teaching purposes and students.

Use of Technology

In the first cycle (Grades 1–4), technology assists mathematics and science instruction, both as a research tool and as a means to interact with numbers and geometric figures. Due to a national effort to make technology available to every child in Portuguese schools—the national Technological Plan for Education—teachers and students have their own computers to work on in class and can access the Internet at school.[9] Curriculum recommendations invite teachers to use computers in the classroom.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

From Grade 5, students have specialist teachers for mathematics and science.

Homework Policies

Schools or teachers make decisions regarding homework policies when teachers plan instructional activities with their departments.

Teachers and Teacher Education[10]

Teachers in preprimary, primary, and secondary education receive initial and specialized education, and continuous professional development. Higher education institutions, polytechnic institutes, and universities provide initial teacher education. Prospective preprimary and primary teachers enroll in teacher education programs at colleges (*Escolas Superiores de Educação*) that are part of polytechnic institutes or universities. Universities provide teacher education programs for prospective lower- and upper-secondary teachers. Teaching diplomas designate the subjects, subject areas, or groups of subjects that a teacher can teach.

To enter the profession, teachers must possess a professional qualification conferred by a polytechnic institute or a university for the relevant education cycle. Currently, a master's degree is the minimum academic qualification for the teaching profession, according to the changes introduced within the Bologna Process.[11] In addition, prospective teachers must pass a knowledge and competencies test designed to evaluate scientific readiness.[a] They also must obtain a grade of "Good" or better in their performance assessment of pedagogic and didactic competencies during their probationary period.

Teachers apply to work in the public sector via a national application and are selected based on academic qualification and professional experience. Teachers working in the public sector are civil servants.

Teacher Education Specific to Mathematics and Science

Continuous professional development is the same for all non-higher education teachers. It aims to improve the quality of teaching and learning in core curricular areas of Portuguese language, mathematics, and experimental science, in light of PISA outcomes and the need to invest in system-wide human capital as preparation for the knowledge economy of tomorrow's world. In 2005, the Ministry of Education launched programs of in-service teacher education for first cycle teachers in Portuguese language, mathematics, and experimental

a This test is a recent requirement; first application is assigned for 2013.

teaching of science. These programs also are part of a broader strategy to develop professional practice among teachers to equip them to meet the challenges of wider structural and organizational reforms in the education system.

The basic model of professional development in Portugal includes one year of training followed by a year serving as a resident trainer in the school cluster. Training in mathematics and science still is conducted in school and relies on classroom observation by trainers chosen by higher education institutes. Despite differences relative to specific subject area needs, professional development programs in mathematics, science, and language are based on the same principles and share the following features:

- They are supervised by higher education establishments responsible for initial teacher training;
- They include individual support, education, and monitoring of teachers in the classroom, and include workshops with teachers from the higher education institutions;
- They are related to career progress, via the credit for participating in professional development; and
- They require teachers to produce specific didactic resources to support first cycle work.

Monitoring Student Progress in Mathematics and Science[12]

Schools define assessment criteria for each cycle and year of schooling, in agreement with guidelines outlined in the national curriculum. In Grades 1–4, the teachers' council proposes the criteria, while in Grades 5–12, curricular departments and cycle coordinators propose the criteria. Student assessment includes diagnostic assessment, as well as formative and summative assessment. Teachers are responsible for assessing students and awarding grades, and internal assessment of students takes place at the end of each term and school year.

National examinations take place at Grade 9 for Portuguese language and mathematics, and at Grades 11 and 12 for a variety of subjects, including science (depending on which subjects the student is enrolled in). Results on national examinations affect a student's assessment and certification.

At Grades 4 and 6, national tests in Portuguese language and mathematics monitor and evaluate the effectiveness of the education system in implementing the national curriculum. Results are not used to assess student progress. However, in 2011–12, Portugal will introduce national examinations for

Portuguese language and mathematics at Grade 6 that will have consequences for individual students.[b]

In the first year of school (Grade 1), no student is retained except due to unjustified absences. In the following three years (Grades 2–4), student progress depends on whether they achieve the essential competencies outlined in the National Curriculum of Basic Education.[13]

Student promotion is decided by grade and by cycle. National policy allows schools to decide if a student can progress to the next grade within the same cycle, even if he or she did not achieve the standards in all subjects. At the end of the second and third cycles (Grade 6 and Grade 9), the Class Council makes student promotion decisions, according to school assessment criteria and national guidelines.

In order to complete secondary-level studies (Grades 10–12), students attending technological, specialist artistic, and vocational courses of study are promoted upon achieving a final grade of at least ten out of 20 on the school summative assessment. Students from scientific-humanistic courses of study undergo additional external summative assessment through national examinations in certain subjects defined by specific legislation.

By the end Grade 9, students complete basic education and receive either a diploma that certifies academic qualifications or a diploma that certifies both academic and vocational qualifications, depending on the course of study students attended during basic education. By the end of Grade 12, students completing secondary education receive one of two kinds of diplomas, depending on the course of study attended: a diploma that certifies academic qualifications, or a diploma that certifies both academic and vocational qualifications.

b A 2013 national examination will be introduced for the same subjects at Grade 4.

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Qatar

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Introduction

Overview of the Education System

The opening of Qatar Elementary School, for boys in 1950 signaled the beginning of formal education in Qatar. In 1952, official curricula were introduced, with textbooks imported from other Arab countries, followed by the opening of the first girl's elementary school in 1956. Since then, the country has developed a comprehensive educational policy, guided by the nation's Islamic heritage and moderate character, as well as a commitment to the development of educational curricula and systems informed by modern technological achievements and new educational research.[1] From 1960 to 2005, the education budget increased from 25 million Qatari riyal ($6.9 million USD) to 3,093 million ($849 million USD). In 2010, approximately 15 percent of Qatar's national budget was allocated to the education sector, with substantial funds being set apart for creating new facilities and constructing academic buildings.[2]

Prior to 2003, Qatar's Ministry of Education oversaw the nations' schools. After 2003, the Qatari government began defining and implementing educational policy via the Supreme Education Council. Since 2003, oversight of Qatari schools has transitioned gradually from the Minstry of Education to the Supreme Education Council.

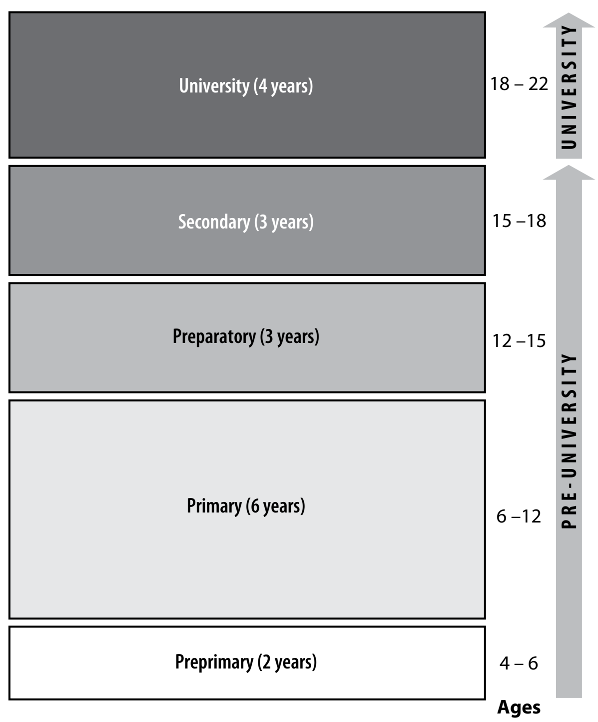
The state provides every Qatari child a free education from kindergarten through university, including textbooks, stationery, transportation, sport kits, and gear for all students at all levels of education. The state also offers financial incentives for Qatari students and organizes religious and cultural events and competitions.

Nearly 80 percent of Qataris under the age of 15 are currently enrolled in public schools, which are separate for girls and boys. In each type of school, teachers are the same gender as their students. Public schools also provide free education for the children of non-Qatari residents who work in the public sector.[3] Despite an initial discrepancy between the number of boys and girls attending school in the 1950s, attendance by gender has been nearly equal since the late 1970s, with girls outperforming boys academically. As of 2009, however, there has been a discrepancy between the number of boys and the number of girls attending private Arabic schools.[4]

In addition to a number of private schools, Qatar has schools for different Arab communities (such as Tunisian, Lebanese, Jordanian, and Sudanese schools) and non-Arab communities (such as Indian, American, French, German, and others). The state of Qatar supports the establishment of various types of private educational institutions and provides continuous legal and supervisory support.[5]

The education system in Qatar consists of three stages—primary (six years), preparatory (three years), and secondary (three years). Education is compulsory through the preparatory (intermediate) level. Education at the preparatory level is predominantly in general education public schools; preparatory religious schools enroll only a very small percentage (0.5%) of students. At the secondary level, 98 percent of students are enrolled in general education, 1.7 percent in vocational education, and 0.5 percent in religious education. The stages of Qatar's education system are shown in Exhibit 1.

Exhibit 1: Education System in Qatar



Until 2003, the Qatari education system, under the Ministry of Education, was highly centralized, hierarchical, and uniform in its organization and operation. For schools governed by the Ministry of Education, the curricular unit of the Arab Bureau of Education for the Gulf States (ABEGS) determined what should be taught and the objectives to be included in textbooks. The bureau relied heavily on curriculum experts and designers with both previous teaching experience and external expertise in designing curricula consistent with the culture of each state.

To assist in the development and implementation of educational reform, the Supreme Education Council was established by emiri decree in 2003. The council consists of three institutes: the Higher Education Institute, the Evaluation Institute, and the Education Institute. The Higher Education Institute advises individuals about career options and opportunities for higher education in Qatar and abroad, and administers scholarships and grants. The Evaluation Institute oversees a highly innovative evaluation component to ensure that decision makers have access to high quality, objective information. Operating under the Supreme Education Council, the institute is responsible for determining whether students are learning and schools are educating. Consequently, the institute has two primary roles: informing schools, teachers and students about their performance, thus stimulating reflection and improvement; and supplying information to parents and other decision makers on the extent to which schools are fulfilling their roles. This information will assist parents in selecting the best schools for their children and allow school systems to assess the effectiveness of each school. Lastly, the Education Institute develops curriculum standards, provides professional development opportunities to teachers and principals, and monitors schools' financial management through periodic reports and audits.

In 2004, the government began the Education for a New Era initiative to develop general education in Qatar. The Supreme Education Council is the main decision maker in this initiative, which aims to provide the best education for Qataris, preparing them to meet the demands related to economic and social development. Although Qatar's system of public education is centralized at the national level, under the Education for a New Era initiative schools are allowed their own school boards that make decisions regarding appropriate educational measures.[6]

A major emphasis of the initiative is the founding of new "independent schools," which are a type of charter school. Independent schools are government-funded schools that are granted autonomy to carry out their educational mission and objectives while being held accountable to the Supreme Education Council, which designates them as independent. These schools foster the kind of creativity and critical thinking the 21st century demands by offering new models for curriculum design, teaching methods, and collaboration,[7] and they are granted more freedom in choosing teaching techniques and methods used to apply the national standards, compared to schools governed by the Ministry of Education.

Since 2004, the transition of governance of Qatari schools has been gradual. By the end of the 2010–11 academic year, all Ministry of Education schools had become independent schools, overseen by the Supreme Education Council, at which point the Ministry of Education ceased to exist. For these schools, the Curriculum Standards Office is now responsible for establishing rigorous curriculum standards in Arabic, English, mathematics, and science—the subjects deemed essential for Qatari citizens.

In order to support and guide the implementation of the Education for a New Era initiative, Qatar has developed a state-of-the-art education management information system called the Qatar National Educational Data System. This system includes an assessment component, the Qatar Comprehensive Educational Assessment program, and the Qatar Comprehensive Survey System, which is a set of surveys of key educational stakeholders.

Curriculum standards are an important part of education reform efforts. These standards identify what should be taught at each grade level, set out goals for learning, and reflect what Qatari students should know, understand, and be able to do at each grade level. Because the standards are based on international benchmarks, students who meet the standards should be competitive for college admission and jobs throughout the world.

The Curriculum Standards Office is responsible for establishing rigorous curriculum standards for independent schools in four subjects: Arabic, English, mathematics, and science. The national language, a second language, mathematics, and science are referred to as core subjects because student progress in other subjects often depends on progress in these four areas. These core subjects are taught in nearly every state to all students. Other subjects may be taught in independent schools, but they may vary from school to school.[8]

Languages of Instruction

According to the 2010 census, the total population of Qatar was 1,699,435.[9] Arabic is the official language and the language of instruction, although a few years ago some schools started teaching mathematics and science in English to predominantly native Arabic-speaking students. Farsi, Balochi, Pashto, and Urdu are among the many languages and dialects spoken by Qatar's large expatriate community. English is the common language spoken among Western expatriates, although bilingualism and language switching between Arabic and English are commonplace among Qataris and expatriates.

Mathematics Curriculum in Primary and Lower Secondary Grades

The following is a summary of what mathematics students should know and be able to do by the end of Grade 4: [10]

- Reasoning and Problem Solving—Represent and interpret mathematical problems using calculations, mathematical symbols, diagrams, graphs, charts, and tables; explain in their own words orally, in writing, or by using diagrams, the method used to solve a problem or why an answer is correct; check that results are appropriate in the context of the problem and justify their reasoning in simple cases.
- Number and Algebra—Represent whole numbers and decimals to two places in expanded form and use their understanding of place value to order numbers and to multiply and divide by multiples of 10 and 100; round whole numbers to the nearest 10 or 100; round decimals to the nearest whole number, and estimate answers to calculations; identify multiples of one-digit numbers and extend and find missing numbers in a simple linear sequence; know multiplication and division facts to 10×10 and use factors to simplify mental multiplication and division calculations; choose, use, and explain written column methods to multiply and divide three-digit by one-digit whole numbers, multiply three-digit by two-digit whole numbers, add and subtract decimals to two places, and multiply a decimal with up to two places by a one-digit whole number; add and subtract two simple fractions either with the same denominator or with different denominators, one of which is a multiple of the other, and express the answer as a mixed number; and solve problems with up to two calculation steps using whole numbers, or using one calculation step using decimals, including real-life problems related to money or measures.
- Geometry and Measures—Identify parallel and perpendicular lines, recognize lines of symmetry, and complete symmetrical figures; identify angles as greater than or less than a right angle, and order a set of acute and obtuse angles by size; identify simple properties of squares,

rectangles, and parallelograms; construct squares and rectangles on grids and use a ruler to draw lines to the nearest millimeter; solve simple problems involving scale; find the perimeter of irregular polygons and perimeter and area of shapes that can be split into squares and rectangles; choose and use suitable units to estimate and measure as well as read scales with accuracy; convert centimeters to meters or millimeters using decimal notation; and express time intervals in minutes.

- Data Handling—Complete, extract, and interpret information presented in lists, tables, and diagrams; and solve problems using data presented in bar graphs and tables.

The following is a summary of what mathematics students should know and be able to do by the end of Grade 8: [11]

- Reasoning and Problem Solving—Solve routine and non-routine mathematical problems in a range of contexts; represent and interpret problems and solutions in numeric, algebraic, geometric, or graphical form, using correct terms and notation; choose and use appropriate mathematical techniques and tools, including ICT, to solve problems; use diagrams and text to explain problem solutions and support them with evidence; present a concise, reasoned argument orally and symbolically; use step by step reasoning to deduce properties or relationships in a given geometric figure; find a counter-example to show that a conjecture is false and begin to consider special cases; and find alternative solutions to problems.

- Number and Algebra—Solve routine and non-routine problems by calculating accurately with positive and negative whole numbers, decimals, and fractions, as well as with percentages, ratios, and proportions; select the appropriate mental, written, or calculator method when applying the commutative, associative, or distributive laws; estimate and calculate positive integral powers of numbers as well as square and cube roots and use the power and root keys of a scientific calculator when appropriate; simplify and evaluate algebraic expressions and formulas, and find the sum or difference of simple algebraic fractions with integer denominators; formulate and use linear expressions to model situations; construct and solve linear equations, including those with simple fractional coefficients, and determine whether given values satisfy an equation; extend and find missing terms in numeric, geometric, or algebraic sequences, and generalize the relationship between one term and the next, or describe the n^{th} term using symbols; interpret and draw graphs of proportional or linear functions representing practical situations, including distance–rate-time and conversion graphs; and identify, when given the graph of a function, intercepts on axes and intervals where the function increases, decreases, or is constant.

- Geometry and Measures—Identify the symmetries of two-dimensional shapes; calculate interior and exterior angles of polygons; solve problems using angle and symmetry properties of polygons and angle properties of parallel and intersecting lines; identify the reflection, rotation, or translation of a two-dimensional shape, and draw simple transformations, including a combination of two transformations; recognize similar shapes and enlarge shapes by a positive integer scale factor; construct two-dimensional shapes from given information, including scale drawings; visualize and describe three-dimensional shapes in different orientations; convert measurements within systems of units; solve problems involving speed, density, or the volume and surface area of cubes, prisms and cylinders, using a calculator where appropriate; and recognize that measurements are not exact.
- Data Handling—Solve problems by selecting and using an appropriate method of data collection; collect and record continuous data using equal class intervals; recognize that inappropriate grouping of data can be misleading; construct bar graphs, frequency diagrams, and pie charts; compare two data sets using the range, median, mean, and the shape of the corresponding frequency distributions; interpret data sets by drawing conclusions, making predictions, and estimating values between and beyond given points; use data from experiments to estimate the probabilities of favorable outcomes and understand that different outcomes may result from repeating an experiment; and use problem contexts to calculate theoretical probabilities for possible outcomes.

Science Curriculum in Primary and Lower Secondary Grades

The following is a summary of what science students should know and be able to do by the end of Grade 4: [12]

- Scientific Inquiry—Make observations and collect data systematically, plan a fair test by deciding how to control variables, and check and repeat observations to improve accuracy; recognize when conclusions are justified; construct and interpret tables and bar graphs; and handle laboratory equipment correctly; accurately measure length, temperature, mass, and liquid volume.

- Life Science—Recognize the importance of identifying organisms correctly and be able to identify organisms using simple branching keys; know that habitats and their inhabitants are diverse and understand why habitats need to be protected; know that life processes are internally regulated and can be disturbed by injury, illness, and inappropriate actions; recognize the main stages in the life cycles of fish, amphibians, reptiles, birds, mammals, and insects, and describe the main stages in the reproduction of flowering plants, including seed dispersion; know the general effects of tobacco, alcohol, and drugs on the body; and know that some microorganisms can cause illness and that good hygiene helps protect against this.
- Materials—Know that there are three states of matter and that each has particular characteristics; know that ice, water, and steam are different forms of the same substance; be able to measure evaporation rates, identify examples of changes of state in everyday life, and know that changes of state are reversible; recognize that air is a gaseous material and know that it fills spaces between solids; recognize that gases have mass, can flow, and can change their volume; know that there are many different gases and that many are important to humans; and know that metals are an important class of materials, list some common metals, and name the properties that make them useful.
- Earth and Space—Know that the sun casts shadows and that the length of a shadow depends on the time of day, and use this knowledge to make a shadow clock; know how to tell time using a sundial; know that the Earth's rotation causes day and night as well as changes in shadow lengths and positions; and know that the sun is a source of heat and light.
- Physical Processes—Know the difference between heat and temperature, recognize that the temperature of an object rises when heated, and be able to measure temperature accurately; know what causes an object to warm up or cool down; know that some substances are better conductors of heat and be able to compare the insulating properties of different materials; know that sound is a vibration and can vary in loudness and in pitch; know that we hear sounds when they travel through the air to our ears, that having two ears helps us tell where a sound is coming from, and that there are sounds that are either too low or too high for us

to hear; know that loud sounds can damage the ears and that people who work in proximity to noise should wear ear protectors; know that sound travels at a certain speed and be able to explain the occurrence of echoes; and show that sounds can travel through liquids and solids as well as through gases such as air.

The following is a summary of what science students should know and be able to do by the end of Grade 8: [13]

- Scientific Inquiry—Design an experiment, collect data, and make observations in a systematic way, as well as identify patterns, consider the validity of evidence and the extent to which it supports a prediction, and draw conclusions; make working models to illustrate scientific ideas and solve scientific problems; consider how to take representative samples during large investigations and carry out a preliminary investigation to assess practicability; know that scientific work is often done collaboratively, sometimes with colleagues in other countries, and be able to assess the contributions of specific scientists; express qualitative and quantitative information using a range of techniques, including graphs and scale diagrams; use equations to represent chemical reactions; process electronically entered data in appropriate ways; and select and use optical equipment safely and accurately.
- Life Science—Construct and interpret pyramids of energy numbers and biomasses; understand why toxins increase in concentration along a food chain; know the structure of the digestive system and understand the function of enzymes; distinguish between digestion and absorption of food; know the basic anatomy of the lungs and describe the role of the lungs in breathing; know that inhaled air has more oxygen and less carbon dioxide than exhaled air, and that these gases are carried to and from the body's cells via blood vessels; know how smoking affects health; know the difference between red and white blood cells; know the basic structure and function of the human heart and the names and locations of major blood vessels; relate the structure of arteries, veins, and capillaries to their functions; know about diabetes and obesity; describe the structure and function of plant cells involved in photosynthesis; know that green plants make their own food by photosynthesis, which requires light, the chlorophyll in chloroplasts, water, and carbon dioxide, and that oxygen is produced; and be able to give examples of the use of microorganisms in food production.
- Materials—Know that the smallest particle of an element is an atom and that atoms of one element are different from atoms of every other

element; know that compounds are formed from elements and that a molecule is the smallest particle of a compound; represent elements with symbols and compounds with formulas; classify elements according to whether they are solids, liquids, or gases at room temperature and whether they are metals or non-metals; know where the metallic and the non-metallic elements appear in the periodic table and be able to identify reactivity trends for metals in the table; arrange metals in order of reactivity based on their reactions with air, oxygen, water, and dilute acids and know the products of these reactions; know that more reactive metals can displace less reactive ones from compounds in chemical reactions; be able to test for the presence of hydrogen; know that there are a variety of methods used to prevent iron from rusting; know that the ease of extraction of a metal from its ore depends on its position in the reactivity series; know that metals are malleable, ductile, and conductors of heat and electricity, and be able to link the uses we make of well-known metals to their particular chemical and physical properties; contrast the physical properties of metallic and non-metallic elements; know the products of reactions of acids with metals, carbonates, and metal oxides; and be able to name a number of common salts and state their uses.

- Earth and Space—Explain night and day, eclipses, seasons, and phases of the moon in terms of the sun–Earth–moon system; describe the relative positions of the planets and their conditions compared with conditions on Earth, and identify some planets in the night sky; know that the sun is a star and that it radiates light and heat, but that the moon and the planets are visible because they reflect light from the sun; recount a number of uses for artificial satellites; and assess evidence for our modern understanding of the solar system and show how this understanding has evolved over time.

- Physical Processes—Classify common energy forms as kinetic or potential and measure them in joules; know that energy can be transformed from one form to another, and that total energy remains constant during a transformation; know that heat is always produced during energy transformations and that heat dissipation often presents an engineering problem; distinguish between temperature and heat; know that heat is transferred by conduction, convection, and radiation and that radiation can occur in a vacuum; know that the heat conductivity of different materials varies; know the cause of convection currents and how these affect the weather; know how the nature of a surface affects how well it absorbs and radiates heat; know how shadows form, and be able to represent a ray of light with a line; know how light is reflected and refracted and describe applications and examples of reflection and refraction; show how white light can be split into colored light by refraction and give everyday examples of dispersion; know that white light results from the superimposition of red, green, and blue light and be able to apply this to television and to color vision; name factors affecting the strength of an electromagnet and describe some applications of electromagnets in everyday life; and know how a current carrying wire moves in a magnetic field and be able to apply this to the construction of an electric motor.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Materials, Equipment, and Laboratories

Teachers in independent schools use a set of learning objectives based on the strands and objectives that form the core of the Qatar national standards. Some schools opt to use a publishing company to help teachers develop textbooks tailored to the key performance standards established by the school board. All schools in Qatar have science laboratories and all the equipment necessary to foster enhanced instruction in science.

Use of Technology

One of the major benefits of the educational reform currently taking place in Qatar is the provision that schools provide Internet technology tools.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Non-specialist teachers provide instruction in mathematics and science in Grades 1–2. Students have specialist teachers for mathematics and science beginning in Grade 3.

Homework Policies

Formative assessment is one evaluation tool used in by teachers, both to determine the extent of student progress toward educational goals and to provide feedback to the teacher on the progress of student learning. Formative assessment usually includes three stages: data collection, analysis, and revision according to feedback. Homework is one component of formative assessment used in Qatari schools, although Qatar has no national policy regarding homework.

Teachers and Teacher Education

Teacher Education Specific to Mathematics and Science

At a minimum, all teachers of mathematics and science must have a bachelor's degree in mathematics or science. Once recruited, teachers must complete a series of training programs intended to foster and enhance their teaching capabilities. At the school level, teachers conduct peer classroom visits, which are usually scheduled by the subject matter coordinator.

Requirements for Ongoing Professional Development

To improve teachers' assessment techniques, the Supreme Education Council holds item-writing workshops on a yearly basis, which are intended to keep teachers updated on the assessment enterprise and show them how to target key performance standards. Items developed by teachers are then submitted to the Educational Testing Service, the company in charge of designing the Qatar Comprehensive Educational Assessment and tailoring it to the Qatari context. Subject matter experts receive a report on teacher performance, which is used to identify areas of strength and weakness and to identify ways of improving teachers' assessment skills.

The Supreme Education Council (SEC) has placed considerable interest in rehabilitating school leadership and teachers in Qatari schools, in order to achieve the integration of teachers' roles with child rearing and education roles performed by other members in society. Toward this aim, the SEC's Evaluation Institute established the Office of Professional Licenses for teachers and school leaders in 2008. This office gives leaders and teachers in independent schools professional licenses that contribute to raising teacher efficiency. The office also enhances the efficiency of other components of the education system to develop the criteria that form the basis of the Evaluation Institute's evaluation system. Teachers are required to obtain a professional license to teach in all schools in the State of Qatar, in addition to all Independent, private Arabic, and International schools.

Monitoring Student Progress in Mathematics and Science

At the end of every semester, parents of children enrolled in Grades 1–11 in independent schools receive report cards with their children's oral and written examination scores in every subject. Grades 1 and 2 primarily use verbal assessments, while the upper grades use verbal and written assessments along with homework grades. These reports are intended to keep parents up to date on their children's performance, as well as the level of knowledge acquired. Parents may choose to enroll their children in enrichment lessons if performance levels do not meet expectations.

In independent schools, report cards include students' scores based on the formative and summative assessment policy endorsed by the school. In addition, the Supreme Education Council provides parents with reports pertaining to their children's performance on the Qatar Comprehensive Educational Assessment.[14] Following the dissemination of results, parents and class teachers receive reports of student scores in relation to performance benchmark levels set by experts and teachers through a performance-level-setting workshop. Student performance is categorized into three levels of performance benchmarks—meet standard, approach standard, and below standard.

Impact and Use of TIMSS

Since participating in TIMSS, the Supreme Education Council has given increased attention to mathematics and science instruction. Currently, the council is providing professional development for mathematics and science teachers to enhance their teaching capabilities and strategies, and to facilitate their use of technological resources. Efforts have been made in the Supreme Education Council to develop curricula for mathematics and science that emphasize the importance of critical thinking and problem-solving skills.

The decision for Qatar to participate in international studies, such as TIMSS, PIRLS, and PISA, was made largely because international comparative studies about student knowledge and skill levels enhance the capacity of policy analysts, decision makers, educators, and the general public to track the progress of Qatari education reform. It is expected that past achievements in these studies will help build a culture of assessment so that stakeholders regard assessment as a tool for educational reform and change. Qatari education authorities are determined to continue to reform the system and promote the fact that these international surveys are unbiased indicators that provide perspective about the status of the education system in Qatar compared to international standards.

Establishing a culture of assessment is one of the goals of the educational reform already underway in Qatar. With time, increased accountability and transparency will be adopted as the basic tenets of effective educational reform. Recently, the Supreme Education Council introduced an information network whereby teachers are able to access and use items and stimuli from an item bank network developed by the Evaluation Institute. Teachers also are able to access national reports of student performance on the national examination, the Qatar Comprehensive Educational Assessment, as well as international studies, such as TIMSS, PIRLS, and PISA (once results are disseminated and national reports are finalized).

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Romania

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Introduction

Overview of the Education System

Education Act 1 of 2011 currently governs education in Romania. The law emphasizes education as a national priority and describes it as a democratic, differentiated, and continuous process.[1]

The main components of the Romanian education system are preschool education, compulsory education (primary and lower secondary education), upper secondary education, technical and vocational education and training, post-secondary or non-tertiary education, and tertiary or higher education.

Preprimary education is provided to students ages 3–5 or 6 in both public and private kindergartens. At the time of the TIMSS 2011 assessment, compulsory education in Romania started with Grade 1, when children reach ages 6 to 7, and ended at the completion of tenth grade, when students reach age 16. A national examination marks the end of lower secondary school. The upper secondary system is divided into two cycles: high school lower cycle (Grades 9–10), and high school upper cycle (Grades 11–12 or 13). At the time of the TIMSS 2011 assessment, the first cycle of upper secondary was compulsory.

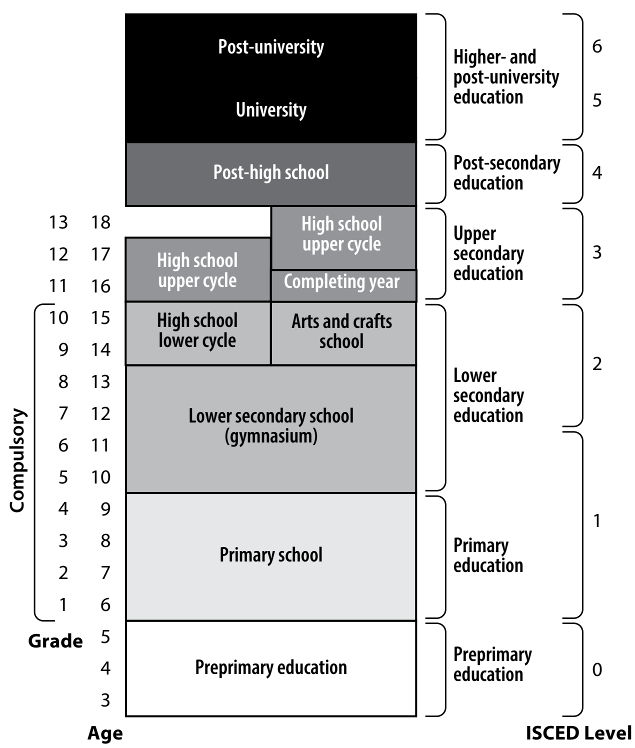
Exhibit 1 presents the structure of the educational system that was in place during the 2011–12 school year—the year in which TIMSS 2011 was assessed.

As of September 2012, the following major education reforms outlined by Education Act 1 of 2011 will be implemented: [2]

- Increasing the duration of primary education from four to five years (Grades 0–4) by introducing a preparatory grade;
- Decreasing the duration of lower secondary education from six to five years (Grades 5–9), and thereby increasing upper secondary education from two or three years to three or four years (Grades 10–12 or 13);
- Modernizing the school curriculum by making it more engaging;

- Reorganizing the student assessment system;
- Ensuring a higher degree of decentralization, accountability, and financing of the system by transferring responsibilities to the School Board of Administration and local authorities;
- Creating more sustainable mechanisms for ensuring disadvantaged groups equal opportunities for education;
- Upgrading vocational education and training (VET) by extending the use of the credit transfer system (i.e., between upper secondary vocational education and post-secondary education);
- Providing the possibility of completing at least one vocational training program to lower secondary education graduates younger than age 18 who had previously left school; and
- Stimulating lifelong learning by recognizing and certifying skills acquired through formal, non-formal, and informal education contexts.

Exhibit 1: Romanian Education System at the Time of the TIMSS 2011 Assessment



Presently, two components comprise the frameworks for primary and secondary education: the national (core) curriculum, a common and compulsory offering established at national level for all students; and the school-based curriculum, a set of educational processes and learning experiences proposed by every school directly to students.

Languages of Instruction

Romania faces complex language challenges in education stemming from its multicultural milieu. Eighteen officially recognized national minorities live in Romania: Albanians, Armenians, Bulgarians, Croats, Slovenes, Czechs, Germans, Greeks, Hungarians, Italians, Jews, Lippovan-Russians, Poles, Roma (Gypsies), Serbs, Slovaks, Tartars, Turks, and Ukrainians. Together, these minorities represent approximately 10 percent of the country's population. Hungarians, the most important national minority in Romania, account for 7.1 percent of the entire population.[3]

The official language of instruction is Romanian, but instruction also is provided in the language of linguistic minorities for all levels of compulsory education. For the Hungarian minority, instruction in Hungarian is guaranteed for all levels, including higher education. Traditionally, some schools (public or private) and university departments also provide instruction in English or German.

Mathematics Curriculum in Primary and Lower Secondary Grades

According to the national curriculum, mathematics education in the compulsory school system aims to build students' understanding of the nature of mathematics as a problem solving activity, based on a corpus of knowledge and procedures that can be approached by exploration. Mathematics also is a dynamic discipline, closely related to society by its relevance to everyday life, technology, the natural sciences, and the social sciences.[4] Exhibit 2 presents the (intended) major shifts in mathematics classroom activities based on curriculum reform conducted from 1998 through 2000.

Exhibit 2: Shifts in Classroom Activities for Teaching and Learning Mathematics

Classroom Activities Should De-emphasize	Classroom Activities Should Emphasize
Memorizing rules and computing.	Problem-solving activities involving trial-and-error, active involvement in practical contexts, and search for solutions beyond the given frame of school knowledge.
Solving problems or exercises that have a unique answer.	Formulating questions, analyzing steps, and motivating decision-making in problem solving.
"Pen and pencil" (or "chalk and blackboard") mathematics.	Using various manipulative activities to help learning.
The teacher acting as an information provider to a student, who receives it passively and works alone.	The teacher acting as a facilitator of learning, stimulating students to work in teams.
Assessment with the purpose of labeling students.	Assessment as a part of learning, and stimulating classroom activities.

However, despite emphasis on modifying mathematics teaching and learning in recent years, the provisioned reforms have not reached the majority of teachers and students due to various changes in educational policies over the last decade. Consequently, the reforms have not effectively influenced student learning.

Exhibit 3 presents the mathematics framework objectives and curricular achievement standards for the primary education level (Grades 1–4).[5]

Exhibit 3: Objectives and Achievement Standards for Mathematics Curriculum, Grades 1–4

Framework Objectives	Curricular Achievement Standards
1. Knowing and using specific mathematical concepts, terminology, and computing procedures.	Read and write numbers up to 1,000,000; Use mathematical terminology correctly; Perform addition and subtraction with natural numbers smaller than 1,000,000; Perform multiplication and division with natural numbers smaller than 1,000; and Use fractions with the same denominators in simple exercises of addition and subtraction.
2. Developing capabilities for exploration, investigation, and problem solving.	Recognize, represent, and classify two-dimensional and three-dimensional shapes; Formulate and solve problems that involve performing as many as three operations; Use arithmetic reasoning in problem solving situations; Use simple modalities to organize and classify data; Recognize and develop patterns for sequences; Perform estimations and approximations in practical situations; Use unconventional measurement units in various contexts; and Use conventional measurement units for time, mass, length, and volume of objects.
3. Developing the capability to communicate using mathematical language.	Express computing strategies and the results of exercises and problems in a concise and clear manner, verbally and in writing.

Exhibit 4 presents further information about curriculum content, showing the progression in competence development during Grades 1–4 for one of the framework objectives described in Exhibit 3. Specifically, the exhibit presents the progression for the second framework objective—Developing Capabilities for Exploration, Investigation, and Problem Solving.

Exhibit 4: Progression in Competence Development for Mathematics—Developing Capabilities for Exploration, Investigation, and Problem Solving

Reference Objectives for Grade 1	Reference Objectives for Grade 2	Reference Objectives for Grade 3	Reference Objectives for Grade 4
By the end of Grade 1, students will be able to do the following:	By the end of Grade 2, students will be able to do the following:	By the end of Grade 3, students will be able to do the following:	By the end of Grade 4, students will be able to do the following:
Explore ways of writing numbers smaller than 100 as a sum or a difference.	Explore various ways of decomposing numbers smaller than 100.	Explore ways of decomposing positive integers smaller than 1,000, using any known arithmetic operation.	Explore ways of decomposing positive integers less than 1,000, using any of the four arithmetic operations or their combinations.
Estimate the number of objects in a set and check estimation by counting.	Estimate the magnitude of a result of an arithmetic operation in order to limit computing errors.	Perform integer division of a number by a single-digit number and link it to the formula *dividend = divisor x quotient + remainder < dividend*, by using repeated subtraction or multiplication.	Estimate the truth of an assertion and know the sense of the implication "if-then" for simple, everyday examples.
Observe the correspondence between the elements of two sets of objects, drawings, or positive integers smaller than 20.	Observe the correspondence between the elements of two different categories of objects (sequences, numbers less than 100), based on given rules; continue repetitive models represented by objects or numbers less than 100; and Create sequences using given rules.	Discover, recognize, and use patterns in sequences of objects or numbers that are composed by using given rules.	Discover, recognize, and use patterns in sequences of objects or numbers that are composed by using various rules.
		Use symbols for replacing unknown numbers while solving problems.	Use symbols for replacing unknown numbers while solving problems.
Solve problems involving one operation (addition or subtraction); and Devise exercises and problems with numbers between 0 and 20, orally.	Solve problems that require one arithmetic operation from those already studied; Solve problems that require at least two arithmetic operations of addition or subtraction; and Compose exercises and problems with numbers between 0 and 100 that involve one arithmetic operation, orally.	Compose and solve word problems of the following types: *a±b=x, a±b±c=x,* *a x b=x,* *a : b=x, b10,* where a, b, c are given positive integers less than 1,000, and x is an unknown number.	Compose and solve word problems.
	Extract information from tables and lists, collect data by observation, and represent data in tables.	Collect, sort, and classify data based on simple criteria, and organize these data in tables.	Collect, sort, and classify data based on simple criteria, represent these data in tables, and give simple interpretations.

In 2009, formal changes were introduced to the lower secondary education curriculum to align it with the European Framework for Key Competences for Lifelong Learning.[6] The European Parliament and the Council of the European Union recommended the following domains of key competences: communication in the mother tongue; communication in foreign languages; mathematical competence and basic competences in science and technology; digital competence; learning to learn; social and civic competences; sense of initiative and entrepreneurship; and cultural awareness and expression. However, while the intended curriculum was formally changed, the implemented curriculum and, particularly, the curricular achievement standards for the end of compulsory education have remained unchanged.[7] Consequently, teaching practice in Romania has not been impacted.

Exhibit 5 presents the mathematics curricular achievement standards for the end of compulsory education (lower secondary education level).

Exhibit 5: Objectives and Achievement Standards for Mathematics Curriculum, Grades 5–8

Framework Objectives	Curricular Achievement Standards
1. Knowing and using specific mathematical concepts, terminology, and computing procedures.	Write, read, and compare real numbers and represent them on the number line;
	Perform mathematics operations with real numbers (possibly represented by letters);
	Use estimates and approximations of numbers and measurements (length, angle, surface area, and volume) to appreciate the validity of results;
	Use elements of logic and set theory, as well as relations, functions, and sequences when solving problems;
	Solve equations and inequalities and perform algebraic calculations using algorithms, specific formulae, and other methods;
	Establish and use qualitative and quantitative properties of two-dimensional and three-dimensional geometric shapes in problems involving demonstrations and computations;
	Use the relative positions of geometric shapes and elements of geometric transformations; and
	Record, process, and present data using elements of statistics and probabilities.
2. Developing capabilities for exploration, investigation, and problem solving.	Identify a problem and organize its solution efficiently;
	Use various representations and methods to clarify and justify (prove) mathematical statements; and
	Build generalizations in mathematics and check their validity.
3. Developing the capability to communicate using mathematical language.	Understand the overall significance of mathematical information from various sources;
	Express one's own attempts to solve a problem correctly, orally or in writing; and
	Engage in mathematics activities as a member of a group.

Science Curriculum in Primary and Lower Secondary Grades

In primary education, students are guided to develop their knowledge by exploring and investigating the world around them. The objectives pursued involve mainly observing, interpreting, and understanding natural processes and the environment and the impact of human activities on them. The formal curricular documents also encourage students to assume responsibilities and cooperate in groups. Exhibit 6 presents the science framework objectives for Grades 3–4 and the curricular achievement standards that should be attained by the end of Grade 4.

Exhibit 6: Objectives and Achievement Standards for Science Curriculum, Grades 3–4[8]

<table>
<tr><th>Framework Objectives
(Grades 3–4)</th><th>Curricular Achievement Standards for Each Framework Objective
(End of Grade 4)</th></tr>
<tr><td>1. Understanding and communicating using specific science concepts and terminology.</td><td rowspan="3">Identify similarities, differences, and relationships among objects and system components based on observation;
Classify objects, events, and phenomena based on specific criteria;
Describe relationships among systems and system components;
Communicate about experimental results and about objects, phenomena, events, and systems observed in different ways;
Use conventional and unconventional instruments and tools for measurement, and identify patterns while measuring or observing phenomena; and
Conduct basic experiments grounded in hypotheses or working plans.</td></tr>
<tr><td>2. Constructing and developing experiments, making use of specific instruments and procedures.</td></tr>
<tr><td>3. Developing interest in and responsibility for environmental sustainability.</td></tr>
</table>

The focus in secondary school science classes continues the focus on observing natural processes and the impact of human activities on the environment. Other aspects concern awareness of interdependencies among biological, physical, and chemical systems, while encouraging students to assume responsibilities and cooperate in groups. The curriculum is aligned as closely as possible to the eight key competences recommended by the European Parliament and the Council of the European Union (described previously). Following the model of competence development for secondary education, two categories of competencies are defined within the curriculum for each subject: general competencies to be acquired by the students at the end of a school cycle, and specific competencies (achievement standards) that are built throughout a single year of study.[9]

Exhibits 7 through 10 present the general competencies and specific achievement standards for biology, chemistry, physics, and geography during lower secondary education (Grades 5–8).[10, 11]

Exhibit 7: Competencies and Achievement Standards for Biology Curriculum, Grades 5–8

General Competencies (Grades 5–8)	Curricular Achievement Standards for Each General Competency (End of Grade 8)
Acquiring information about the living world. Exploring biological systems. Using and developing models and algorithms to demonstrate principles of the living world. Communicating orally and in writing, using correct terminology. Transferring and integrating specific knowledge and methods of biology in new contexts.	Use terminology and concepts correctly to describe and interpret biological processes; Identify, interpret, and classify structural and functional properties of organisms; Carry out research on the living world by correctly applying investigative methods; Identify a problem and select correct methods and means to solve it; Interpret and comment on data collected while carrying out an experiment and draw conclusions from the data; Present one's own research activities, verbally or in writing; and Select and use appropriate sources of information.

Exhibit 8: Competencies and Achievement Standards for Chemistry Curriculum, Grades 5–8

General Competencies (Grades 7–8)	Curricular Achievement Standards for Each General Competency (End of Grade 8)
Explaining chemical phenomena, processes, and procedures from daily life. Investigating how substances and chemical systems behave. Using deductive and inductive approaches to solve problems. Explaining and reporting results of investigations. Evaluating consequences of using chemical processes and chemical products.	Classify simple and complex substances, mixtures, and chemical reactions according to one or more criteria; Describe and interpret chemical phenomena, properties, and models; Experiment using known substances; Represent and interpret observations and data resulting from research and experiments, in the form of tables, graphs, and diagrams; Draw conclusions based on the physical and chemical behavior of substances; Apply mathematics relations and expressions of chemistry laws to solving quantitative problems; and Use scientific terminology when presenting a piece of research, verbally or in writing.

Exhibit 9: Competencies and Achievement Standards for Physics Curriculum, Grades 5–8

General Competencies (Grades 6–8)	Curricular Achievement Standards for Each General Competency (End of Grade 8)
Knowing and understanding physical phenomena, concepts, laws, and models, and explaining the function and use of technical devices in daily life.	Describe observed physical phenomena, using specific terms; Use measuring equipment and specific methods to determine physical quantities; Carry out experiments, either controlled or not, starting from physical phenomena; Organize, use, and interpret data from experiments; Interpret the content of a problem from the perspective of physics, quantitatively; Use mathematical relations and principles and laws of physics to solve theoretical or practical problems; Use physics terminology to describe observations and conclusions drawn from experiments; and Understand the overall meaning of physics-related information from various sources.
Investigating experimentally and theoretically.	
Solving problems using specific procedures from physics.	
Communicating using scientific terminology.	
Protecting human beings and the environment.	

Exhibit 10: Competencies and Achievement Standards for Geography Curriculum, Grades 5–8

General Competencies (Grades 5–8)	Curricular Achievement Standards for Each General Competency (End of Grade 8)
Using correct terminology to present and explain geographic reality.	Define correctly the position of basic elements in space and time; Connect elements of real geographical space with their symbolic representations; Use information from maps and drawings to represent a geographical reality; Write a report on a topic related to geography; and Use information communication technology (ICT) to look for and find geographic information.
Using names and terms in different languages.	
Transferring knowledge from mathematics and science to environmental studies.	
Displaying geographic reality in maps.	
Identifying and explaining social, civic, and cultural dimensions of geographic space.	
Acquiring skills and techniques for lifelong learning.	
Developing patterns and solutions for organizing geographic space, taking into consideration sustainable development.	

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Materials, Equipment, and Laboratories

Teachers are responsible for selecting textbooks and deciding teaching, learning, and assessment methods based on students' prior knowledge, the availability of teaching materials, and accepted teaching practices. In primary and secondary education, teachers can only use textbooks and auxiliary materials that have been approved by the Ministry of Education, Research, Youth and Sports in the classroom. Since 1996, textbooks have been selected from a list of manuscripts in a national competition, which includes judging content using several criteria in addition to a cost bid. Teachers are free to choose from the official, ministry-approved list of textbooks that have been successful in the competition. In compulsory education, the government pays for textbooks. Teachers usually use mathematics and science textbooks as sources for practice classroom exercises. Teachers also might receive teaching guides, which are not compulsory.

Various resources may be used in mathematics teaching—objects, geometrical figures, drawings, or computers—but not calculators. The role of hands-on activities is very important in primary school, where students use different objects (e.g., sticks or marbles) to calculate. In later grades, different measurement instruments are emphasized, and models of geometrical shapes are used to help students visualize abstract forms.

Most schools have science laboratories for physics, chemistry, or biology, but schools are responsible for buying laboratory equipment.

Use of Technology

The systematic use of ICT in instruction is relatively limited. Some national programs focus on technology integration as well as educational software for teaching mathematics and science. However, typical schools do not have enough equipment for one-to-one instruction and frequently there are problems with maintaining existing equipment. Consequently, computer use in teaching, learning, and assessment depends on local resources.

Grades at Which Students Specialist Teachers for Mathematics and Science Are Introduced

In Grades 1–4, one teacher teaches all subjects with some exceptions (e.g., foreign languages and religion are taught by specialized teachers). In lower secondary grades, a single specialized teacher teaches each subject and is free to develop his or her own teaching methods. The curriculum does not impose specific instructional methods, but offers examples of learning activities. Practical (hands-on) activities and problem solving are relatively important but not regarded as compulsory, and advanced classroom management is known and used by a small number of teachers.

Homework Policies

There is no official policy regarding homework. However, the tasks that teachers give in mathematics and science for students to work on at home are compulsory.

Teachers and Teacher Education

Teacher Education Specific to Mathematics and Science

At the primary education level, the minimum requirements for teacher education and training used to be graduation from a pedagogical high school. Recently, these requirements were revised; now teachers must complete a bachelor's degree and a 60-credit program in the psycho-pedagogical field.

At the lower secondary education level, the minimum requirements for teacher education and training also involve graduation from a higher education institution and 60 credits of psycho-pedagogical preparation. Based on their field of study and area of specialization, most teachers in secondary education are qualified to teach a single subject. Some teachers qualify to teach an additional subject by completing postgraduate coursework.

The current teacher education system is in the process of changing. According to the new education law, teachers will be required to obtain a master's degree. During the last several years, a few universities have developed master's degree programs for training teachers. The most successful system proved to be a four-semester program that took place in a blended learning environment; the development of teaching competences was stimulated by involvement in face-to-face activities and an individualized approach specific to online instruction.[12] This program also brought innovation to curriculum design. Specifically, subjects were grouped into a specialization domain defined by the following: a core curriculum offering fundamental knowledge about a specific subject (e.g., mathematics); a specialized curriculum focusing on the main domains of a teacher's training (e.g., didactics of algebra or geometry); and a functional curriculum focusing on subjects derived from the specific social needs of contemporary society (e.g., communication, ICT, entrepreneurship, and management of values). Tutorials for conducting educational research and preparing graduation papers also were included.[13]

Other attempts to update teacher education programs come from innovations in organizing the way each university delivers pedagogical courses for its prospective teachers. For example, a few universities have based didactics of mathematics instruction (a course offered in the second year of university study) on monitoring prospective teachers as they implemented small-scale research projects in their practice schools. The use of projects seemed to be very effective in helping teachers acquire teaching knowledge and understanding.[14]

Requirements for Ongoing Professional Development

Teacher professional development is a process with several stages, beginning with teacher certification and continuing as teachers attain higher levels of mastery, including achieving second-degree and then first-degree teachers status. Teachers also participate in professional development once every five years. The minimum standard for regular professional development is 90 professional transferable credits.

Monitoring Student Progress in Mathematics and Science

Classroom teachers assess students on a regular basis in all subjects, compulsory and elective. Teachers establish assessment methods and instruments, which can include oral questioning, written papers, practical activities, reports and projects, interviews, and portfolios. The most frequently used mathematics assessments include tests and traditional exercises (oral and written); project work and self-assessments are seldom used.

In primary education, student attainment is graded using qualitative descriptors (i.e., insufficient, sufficient, good, very good, and excellent), according to the curricular standards and descriptors established at the national level for each subject and grade. In order to progress from one grade to the next, students must achieve at least “sufficient” as their final average qualitative descriptor for each subject.

In secondary education, teachers give students grades on a scale from 1 to 10. At this level, students can progress from one grade to the next (within the same education level or cycle) if they obtain a final academic average of at least 5.00 and a final behavior average of at least 6.00 for each subject studied during the school year.

The first official examination to include mathematics takes place at the end of lower secondary education (Grade 8 or 10, depending on the track). This examination’s role is to certify graduation from compulsory schooling and provide access to upper secondary education. National assessments are conducted periodically on a representative sample of students at the end of the fourth grade. Science is not assessed nationally in upper secondary education.

Impact and Use of TIMSS

For many years, TIMSS studies have provided the only reliable assessment of the Romanian education system. TIMSS data raised policymakers’ awareness concerning the effectiveness of the education system, the problems facing the system, and the necessity for change to both instructional content and teaching practice.

During 2011, extensive attention was paid to the country's participation in TIMSS 2011, because Education Act 1 of 2011 states that national assessments should be designed using international evaluations as examples of good practices. Thus, the assessment design for fourth grade reading comprehension, mathematics, and science will emphasize the principles followed by IEA studies, and collections of released items will become available for the public (students, teachers, and parents) on a special website. TIMSS released items will be analyzed from the perspective of their cognitive approach, and also from their relevance to the national curriculum. This analysis will lead to reports highlighting typical student misconceptions in learning mathematics and science. Based on the TIMSS 2011 results, methodological guides for learning mathematics and science will be developed. These will contain a set of suggestions for improved instructional practices, in hopes of strengthening current mathematics and sciences teaching practices.

Romania has entered into a partnership project with IEA, which will consist of four training sessions for conducting secondary analyses of TIMSS 2011 data. Within this project, some studies will identify means to reduce the achievement gap between high and low achievers, and between high performing and low performing schools.

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The Russian Federation

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Introduction

Overview of the Education System

Under the current Law on Education passed in 1992, the Russian education system has become more decentralized in its decision-making and funding practices. According to the law, the government guarantees citizens of the Russian Federation free general education and, on a competitive basis, free vocational education at state and municipal educational institutions.

Education policy is developed at the national level and implemented at regional and local levels under the oversight of the national authorities. Legislation attempts to establish a balance between national, state, and provincial oversight of education as well as autonomy of educational providers. In 2006, the federal law On Autonomous Establishments introduced a new type of educational institution that has a greater degree of freedom in managing its resources. This law aimed to increase the effectiveness of education and support for institutions from state budgets in order to implement more effective and innovative learning technologies.

In the field of education, federal education authorities create federal policy, oversee its implementation, and develop the legislative basis for the functioning of the education system. Furthermore, federal authorities establish federal and state educational standards, elaborating on model curricula and model programs of study for different school subjects on the basis of these standards. The authorities also oversee expert review of textbooks and supplementary literature for schools.[1]

The 1992 Law on Education gave greater autonomy and responsibility to schools. Educational institutions themselves determine programs independently based on documents recommended by central authorities. Federal and local government authorities do not have the right to change the curriculum or an institution's study schedule once approved, except when stipulated by the Russian legislature.

The public system of education includes general education—preprimary, primary, basic, and upper secondary—and vocational education—initial, secondary, higher, and postgraduate. General education (Grades 1–11) is compulsory according to the Constitution of the Russian Federation.

Preprimary education is for children ages 3–6, and is not compulsory. In 2010, preprimary education included 45,100 preprimary institutions serving 5,388 million children.[2] Because of the significant increase in the birth rate during the last five years and the lack of necessary kindergartens, new types of institutions, including family kindergartens, have been established.

Primary general education consists of Grades 1–4 and may be provided in primary schools, in basic schools that include the primary stage, and in secondary education institutions that include all three stages. Basic general education or lower secondary education consists of Grades 5–9, while secondary general (or upper secondary) education covers Grades 10–11. Because general education is compulsory, if a student finishes basic school (Grade 9) and wishes to attend vocational school, he or she will study both general education subjects (equivalent to Grades 10–11, but at a basic level) as well as vocational education subjects and training.

Several types of schools provide general education: general schools, schools specializing in specific disciplines, gymnasia, lyceums, evening schools, boarding schools, and schools for children with special needs. Schools with higher educational standards, such as gymnasiums, offer a broad, humanities-based education, while lyceums are mainly oriented to university preparation. Some schools also offer in-depth education in specific subjects.

Approximately 99 percent of all primary, basic, and secondary schools in Russia are public-municipal, meaning that the municipal budget is the school's main source of financing and that many decisions are made at the regional level. In the 2010–11 school year, there were 50,100 public-municipal schools with 13,569,000 students.[3, 4] In 2011, there were 687 non-public general education institutions that catered to only 0.62 percent of students.[5]

Despite the fact that the 2004 national curriculum has not yet been fully implemented, new strategic goals were formulated in 2006. These goals seek to provide innovative, long-term development and include new requirements for young people's preparation to assume professional and social roles. The new educational standards emphasize key competencies, personal creative development, and interdisciplinary outcomes.

Beginning with primary schools in 2011, the new standards of general education, based on the goals introduced in 2006, are being developed and introduced gradually in schools. The structure of the new education standards is outlined in federal law, and it includes three types of requirements: [a]

- The structure of the main curriculum and programs;
- Requirements for the conditions of program realization; and
- Requirements for achievement results.

In January 2010, the president of the Russian Federation approved the Our New School initiative, which includes the following five main goals:

- New federal standards to provide higher quality of education;
- Activities for gifted children;
- Development of teacher potential (including new teacher professional development models, new certifications for teachers, and new initial teacher education centers based in existing pedagogical universities and institutes);
- Improvements in the infrastructure of school networks; and
- Improvement of student health.

The Russian education system reform shares the following five features with other countries in the world:

- The transition to competence-based standards;
- The creation of a national system of independent school examinations;
- The use of school self-evaluations and increased understanding of their importance;
- Public involvement in school management at different levels (municipal, regional, and national); and
- Changes in the nature of evaluation from a quality control to a quality assurance focus.

Fundamental social transformations in Russia have influenced major changes in mathematics and science education. Humanitarian, cultural, and pragmatic components of mathematics and science have gained a new emphasis, with the general intellectual and cultural development of students being one of the principal objectives for teaching these subjects. The focus is on finding a balance between academic and human or social aspects in teaching mathematics and science and developing new standards for school outcomes.

a The federal law on the new education standards, Law #309, was introduced December 1, 2007.

In formulating content and learning outcomes, emphasis has shifted from rote learning and reproduction of rules, definitions, concepts, schemes, and algorithms for understanding to intelligent application in the solution of different kinds of learning and cognitive problems in familiar and unfamiliar situations.

Languages of Instruction

Russian is the official language of the Russian Federation. In the majority of schools (more than 95%), Russian is the language of instruction for all subjects, including mathematics and science in fourth and eighth grades. However, some students receive instruction in one of the country's national ethnic group languages; today, 39 languages are used as languages of instruction.

Mathematics Curriculum in Primary and Lower Secondary Grades

For all three stages of general education (Grades 1–11), the mathematics national curriculum includes the goals of mathematics education, the requirements for student achievement (what students should know and be able to do at the end of each stage of general school) and the instructional content (mandatory minimum content) that must be presented to ensure achievement of these requirements. The summary of the mathematics national curriculum described below lists the compulsory minimum content as well as some topics and concepts that are taught as preparation for future study (although they are not assessed at the end of the primary stage of general education).

Students who participated in TIMSS 2011 were taught in accordance with the State Education Standards of General Education issued in 2004.[6] For mathematics education in Grades 1–4, emphasis in these standards was placed on the development of mathematical culture and application of knowledge and skills in practical situations and everyday life. This emphasis was implemented as part of the requirements for student achievement, which included orienting themselves in their surroundings, comparing and ordering objects by various characteristics, solving everyday problems, estimating the size of various objects, and self-guided activities. Requirements relating to some topics (e.g., algebra) were reduced if they were connected with material that had traditionally been studied in basic education (Grades 5–9). Also, there was an increased emphasis on the use of mathematics concepts and terminology rather than memorizing mathematical facts.

According to the 2004 national mathematics curriculum, the focus in primary education (Grades 1–4) is on the following:

- Developing students' visual and logical thinking, imagination, and mathematics language, and forming the skills necessary for solving theoretical and practical problems as well as for further education;
- Mastering foundations of mathematics knowledge and forming initial ideas of mathematics as part of a universal culture; and
- Developing interest in mathematics and aspirations to use mathematics knowledge in daily life.

Exhibit 1 presents the compulsory minimum mathematics content for primary education.

Exhibit 1: Compulsory Minimum Mathematics Content for Primary Education, Grades 1–4

Topic Area	Minimum Content for Mathematics Grades 1–4
Numbers and Calculations	Counting objects; knowing the name, sequence, and meaning of numbers from 0 to 1,000,000; classes and categories; number relationships, such as "equal to," "more than," or "less than," and writing these relationships using signs (e.g., =, <, and >);
	Addition, subtraction, multiplication, and division of numbers, and use of the corresponding terms; addition and multiplication tables; division with a remainder; and arithmetic operations with zero;
	Determining the order of operations in numerical expressions and finding values of numerical expressions with or without brackets;
	Commutative properties of addition and multiplication and distributive properties of multiplication over addition and addition over multiplication;;
	Oral and written calculations with natural numbers; using the properties of arithmetic operations in the performance of calculations; defining an unknown component of an arithmetic operation (mastery of this content is not monitored); and knowing ways to verify the correctness of calculations;
	Comparing and ordering subjects based on different attributes, such as length, weight, capacity, and time; knowing units of length, weight, capacity, and time; and relationships between units;
	Establishing relationships between the values that describe processes, such as movements, work, and purchases;
	Constructing elementary logic expressions such as "and" and "if"; and
	Solving word problems by using arithmetic (with the support of schemata, tables, brief records, and other models).
Spatial Relations, Geometric Figures, and Geometric Measurements	Determining spatial relationships (e.g., above or below, to the left or right, from above or from below, closer or further, in front or behind, before, after, and between); and
	Recognizing and drawing geometric figures (e.g., points, lines, segments, angles, and polygons); recognizing circumferences and circles and cubes and spheres; measuring the length of a segment and constructing a segment of a given length; calculating the perimeter of a polygon, the area of a geometric figure, and units of an area, as well as the area of a rectangle.

By the end of primary education, students must meet the following achievement requirements in mathematics:

- Know or understand the sequence of numbers up to 100,000; the table of addition and subtraction of digits; multiplication tables and the division of digits; and rules regarding the order of operations in numerical expressions.

- Be able to read, write, and compare numbers up to 1,000,000; represent multidigit numbers in an expanded form using knowledge of place value; use mathematics terminology; carry out arithmetic operations orally with results up to 100; carry out division with a remainder up to 100; carry out written calculations (addition and subtraction and multiplication and division of multidigit numbers into one- and two-digit numbers); calculate with zero; calculate the value of numeric expressions containing two to three operations (with and without brackets); verify the correctness of calculations; solve word problems using arithmetic (no more than two operations); use a ruler to draw a segment of a given length and measure the length of a given segment; identify geometric figures and draw them (using a ruler and by hand); calculate the perimeter and area of a rectangle or square; compare measurements based on their numerical values; and express given measurements in various units.

- Use acquired knowledge and skills in practical activities and daily life to orient oneself in the local environment (e.g., plan a route); compare and order objects by different attributes, including length, area, weight, and volume; define time (in hours and minutes); solve problems connected with household situations (e.g., to purchase, measure, and weigh); estimate subjects' approximate sizes; and construct geometric figures.

In the new Federal State Education Standards for Primary Education, published in 2009, the objectives for student achievement (planning results) are presented in two blocks: objectives the primary school graduate has learned, and objectives the primary school graduate would have the opportunity to learn. The model (subject) program for primary school identifies the content of mathematics instruction. A new topic, working with information, was introduced as well as fractions (of the type 1/n), spatial geometric figures, tables and diagrams, and creation and verification of the truth of statements.

At the basic education level (Grades 5–9), the 2004 State Education Standards involve a practical orientation for instruction, including statistics and probability in all textbooks, emphasizing mathematical modeling and the universality of mathematical language, and including mathematics items connected to real-life situations.

In basic education, mathematics education is directed toward achieving the following goals:

- Mastering the system of mathematics knowledge and the skills necessary for its application in practical activities, related subjects, and continued education;
- Developing intellectually, forming the characteristics necessary for a productive life in a modern society, such as clarity and accuracy of thinking, critical thinking, intuition, logical thinking, elements of algorithmic culture, spatial notions, and the ability to overcome difficulties;
- Forming notions about ideas and methods of mathematics as the universal language of science and technology and means of simulating phenomena and processes; and
- Developing one's attitude toward mathematics as part of a universal culture and understanding the importance of mathematics to scientific and technological progress.

Exhibit 2 presents the compulsory minimum mathematics content for basic education (Grades 5–9) and includes four sections: arithmetic; algebra; geometry; and elements of logic, combinatorics, and statistics and probability.

Exhibit 2: Compulsory Minimum Mathematics Content for Basic Education, Grades 5–9

Topic Area	Minimum Content for Mathematics
Arithmetic	Natural numbers, fractions, rational numbers, real numbers, word problems, measurements, approximations, and estimations.
Algebra	Algebraic expressions, properties of powers, equations, and inequalities, solving word problems algebraically, number sequences, functions, and coordinates.
Geometry	Basic geometry concepts and theorems, angles, lines, circumference and circles, intuitive ideas of spatial figures, triangles, trigonometry, quadrangles, polygons, geometric measurements, areas of plane figures, volumes of solids (e.g., cubes, spheres, cylinders, cones), vectors, geometric transformations, and geometric construction using a ruler and a compass.
Elements of Logic, Combinatorics, and Statistics and Probability	Proofs, sets and combinatorics, and statistical data and probability.

Exhibit 3 presents the mathematics achievement requirements students must meet by the end of basic education (Grades 5–9).

Exhibit 3: Mathematics Requirements for Basic Education in the Russian Federation

General Facts and Methods	
Know or understand	Mathematical proofs and algorithms; the application of mathematical formulas, equations, and inequalities for solving mathematical and practical problems; the probabilistic character of many laws of the natural world; examples of statistical regularities and conclusions; how geometry has arisen from practical geodetic problems; examples of geometric objects and statements about them that are important for practice, and real-life problems.
Arithmetic	
Be able to	Carry out arithmetic operations orally; convert numbers from one form to another; compare and carry out arithmetic operations with rational numbers; find, in simple cases, values of expressions with an integer exponent and roots; find values of numerical expressions; find approximations using integers and decimals; use basic units of length, weight, time, speed, area, and volume; and solve word problems, including problems involving ratios and proportions, fractions, and percentages.
Use acquired knowledge and skills in practical activities and daily life to	Solve simple practical problems using reference materials, a calculator, and a computer; orally estimate the result of calculations; examine the result of calculations using various methods; and interpret results in view of the restrictions connected with properties of the processes and phenomena considered.
Algebra	
Be able to	Compose, transform, and find values of algebraic expressions; carry out operations with powers and polynomials and algebraic fractions; transform and calculate values of numerical expressions containing square roots; solve equations and systems of equations and inequalities; solve word problems using algebraic methods; determine coordinates of a point and locate points on the Cartesian plane; recognize arithmetic and geometric progressions and solve problems using formulas for the general term and the sum of the first several terms of a progression; find values of a function represented in various forms and define properties of a function using its graph; use a graphical method for solving equations, systems, and inequalities; and draw graphs of studied functions.
Use acquired knowledge and skills in practical activities and daily life to	Calculate using functions, compose functions expressing the relationship between real data; find necessary formula in reference materials; model practical situations and research constructed models using algebraic methods; describe dependences between physical variables in simple practical situations using corresponding formulas; and interpret graphs representing real dependences between variables.

Geometry	
Be able to	Use geometric language for describing objects; recognize geometric figures; draw geometric figures; carry out drawings according to the context of a problem; carry out transformations of figures; recognize basic spatial bodies in drawings, models, and the environment and draw them; draw sections of spatial figures; carry out operations using vectors and calculate length and the coordinates of a vector and an angle between vectors; calculate values of lengths, corners, areas, and volumes, and define values of trigonometric functions for angles from 0° to 180°; find values of trigonometric functions using a value of one of them; find sides, angles and the areas of triangles, lengths of broken lines arcs of circles, and areas of basic geometric figures and figures composed of them; solve geometric problems using properties of figures and relationships between them and apply additional constructions, algebraic and trigonometric methods, and ideas of symmetry; reason convincingly when solving problems using known theorems and find opportunities for their use; and solve elementary planimetric problems in space.
Use acquired knowledge and skills in practical activities and daily life to	Describe real situations in the language of geometry; calculate with elementary trigonometric formulas; solve geometric problems using trigonometry; solve practical problems connected with geometric measurements (using, if necessary, reference books and instruments); and make constructions using geometric tools (e.g., a ruler, a set square, a compass, and a protractor).
Elements of Logic, Combinatorics, and Statistics and Probability	
Be able to	Perform simple proofs; draw elementary conclusions from statements; estimate the logical correctness of reasoning, use examples for illustration and counterexamples for refutation of statements; extract information from tables, diagrams, and graphs; compose tables and draw diagrams and graphs; solve combinatorial problems by systematically sorting possible outcomes and using the rule of multiplication; calculate average values of results of measurements; find the frequency of events using one's own observations and given statistical data; and find the probabilities of random events.
Use acquired knowledge and skills in practical activities and daily life to	Defend a proof orally; recognize logically incorrect reasoning; record mathematical statements and proofs; analyze real numerical data presented in the form of diagrams, graphs, and tables; solve practical problems in daily and professional activities using operations with numbers, percents, lengths, areas, volumes, time, and speed; solve theoretical and practical problems demanding systematic sorting of possible outcomes; compare chances of random events occurring, estimate the probability of random events in practical situations, and match a model to a real situation; and understand statistical statements.

New Federal State Education Standards for Basic Education, published in 2011, combined mathematics with informatics into an integrated domain (Mathematics and Informatics), which introduced modern knowledge of computer science and information and communication technologies into education. The role of practical activities in mathematics, including "discovery" and project learning was increased to stimulate students' cognitive activity.

Science Curriculum in Primary and Lower Secondary Grades

In primary education (Grades 1–4), science education is provided through a course called the Surrounding World, in which science is integrated with social studies (about 70% science content).

In the last decade, the content of science education in primary education has focused on creating more balance between different science knowledge areas (the proportion of knowledge in geography, physics, and chemistry was increased) and emphasizing the nature of science and its methods. As a result, changes were made in instruction, such as more use of inquiry, projects, and group methods oriented toward intellectual and personal development.

According to the 2004 national science curriculum (in the State Education Standards of General Education), the goals for studying the Surrounding World in primary school are the following: [7]

- Develop skills to observe objects from the surrounding world, describe their characteristics, conduct analyses, make generalizations, and solve problems;
- Master knowledge of the surrounding world, including the unity and differences between nature and society, and understand humans and their place in nature and society; and
- Develop positive attitudes toward the surrounding world, the environment, and intellectual and moral culture, and develop patriotic feelings, including the need to participate in creative activities in nature and society.

Exhibit 4 presents the compulsory minimum science content for primary education (Grades 1–4).

Exhibit 4: Compulsory Minimum Science Content for Primary Education, Grades 1–4

Topic Area	Minimum Science Content
Surrounding World	Nature, society, and individuals.
Primary School Student	Daily schedule of a student, how to get to school, rules about organizing homework, personal hygiene, caring for one's health, and safe behavior.
Nature	Living and nonliving things; natural phenomena; the seasons; the weather; solids, liquids, and gases; water in nature; land forms; plants; animals; variability; conditions for life; and the interconnectedness of plants and animals.
Human Beings and Nature	Structure and main functions of humans, nature and humans, and the influence of human activities on nature.
Earth–Our Planet	The sun, sources of light and heat, and conditions for life on Earth.

By the end of primary education, students must meet the following achievement requirements in science:

- Know or understand the main properties of air and water; basic conditions for living organisms; rules for caring for one's health; and basic rules of behavior at school, on roads, and in the water.
- Be able to determine the characteristics of different objects in nature (e.g., color, shape, and relative sizes); make distinctions between living and nonliving objects in nature; define the parts of a plant; give examples of representatives of different groups of plants and animals and describe their basic features; and show continents, oceans, mountains, plains, seas, and rivers on a map and globe.
- Use acquired knowledge and skills in practical activities and daily life to enrich life experiences and solve problems using observation, measurement, and comparison; orient oneself in a locality with the help of a compass; determine the temperature of air, water, and the human body with the help of a thermometer; establish relationships between seasonal changes in living and nonliving nature; take care of plants and animals; follow the rules of health care and safe behavior; evaluate the influence of humans on nature, follow the rules of behavior in nature and participate in the conservation of nature; and satisfy cognitive interests and search for additional information about native land, native country, and the planet.

The new 2009 Federal State Education Standards for Primary Education emphasize the objectives (planning results) of developing content knowledge and skills, meta-cognitive skills, and personal characteristics. These objectives were reflected in the new science curriculum, which requires organizing the learning process, taking into account all three aspects.

Science education in basic education (Grades 5–9) starts with the integrated course Nature Study in Grade 5, followed by separate science subjects—Biology (Grades 6–9), Geography (Grades 6–9), Physics (Grades 7–9), and Chemistry (Grades 8–9).

The goals for science education in basic education are summarized as follows:

- Acquire knowledge about natural phenomena, basic science concepts, relations, laws, methods of thinking about nature, and the role of science in society;

- Master the skill of using science knowledge to explain various phenomena and processes and the principles of using basic technical equipment to solve problems; conduct observations and experiments; represent experimental results in different forms and reveal empirical relations; and use equipment, devices, and instruments;
- Develop cognitive interests and intellectual and creative abilities in the process of observation; and conduct investigations, solve problems, and independently acquire knowledge, working with different sources of information;
- Develop positive attitudes toward the surrounding world and an environmental culture, recognize the laws of nature and the necessity of prudent use of scientific and technological achievement for further development of society, and develop respect for scientists as well as a positive attitude toward science as part of culture; and
- Use one's knowledge and skills in practical activities and in daily life for the conservation of nature, caring for one's health, and safe behavior.

Exhibit 5 presents the compulsory minimum science content for basic education (Grades 5–9) for all science subjects by the main topics studied.

Exhibit 5: Compulsory Minimum Science Content for Basic Education, Grades 5–9

Topic Area	Minimum Science Content for Grades 5–9
Biology	Biology as part of the natural sciences; biological methods; characteristics of living organisms; the system, diversity, and evolution of living nature; human biology and health; and the interaction of organisms and the environment.
Geography	Sources of geographical information (e.g., geography as part of the natural sciences and geographic models); the nature of the Earth and humans (i.e., Earth as a planet); the Earth's crust and lithosphere; the hydrosphere, atmosphere, biosphere, and soil (i.e., the geographic shell of the Earth); continents and oceans; nature management and geo-ecology; and the geography of Russia.
Physics	Physics and physical methods of nature study, mechanical phenomena, thermal phenomena, electromagnetic phenomena, and quantum phenomena.
Chemistry	Methods of studying substances and chemical phenomena, chemical reactions, the elementary basis of inorganic chemistry, primary ideas about organic substances, the experimental basis of chemistry, and chemistry and life.

For all science subjects, the standards include detailed, formulated requirements that basic school graduates must achieve. For the sake of brevity, Exhibit 6 presents only the basic school achievement requirements for chemistry as an example.

Exhibit 6: Chemistry Requirements for Basic Education in the Russian Federation

Know or understand	Chemical symbols of chemical elements; formulas of chemical substances and chemical reactions; major chemical concepts: chemical elements, atoms, molecules, relative atomic and molecular mass, ions, chemical relations, substances, classification of substances, mole, molar mass, molar volume, chemical reaction, classification of reactions, electrolyte and nonelectrolyte, electrolytic dissociation, and oxidation-reduction; and the major chemical laws regarding conservation of mass, constant composition, and the periodic law.
Be able to	Name chemical elements and compounds of studied classes; Explain the physical meaning of a chemical element's atomic number, numbers of a group, and period to which the given element belongs; patterns of change in element properties according to the periodic law; and bonding; Characterize chemical elements and the structure of their atoms (from hydrogen to calcium) on the basis of their position in Mendeleev's periodic table; the relation between composition, structure, and properties of substances; and the chemical properties of the main classes of inorganic substances; Determine the composition of substances from their formulas, how a substance belongs to definite class compounds, types of chemical reactions, valence and degree of oxidation of elements in compounds, and bonding; Represent formulas of inorganic compounds of studied classes, models of the structure of atoms in the first 20 elements of Mendeleev's periodic table and equations of chemical reactions; Use chemical equipment safely; Determine if a substance is oxygen, hydrogen, carbon dioxide, ammonia, solutions of acids and bases, chloride, sulfur, or carbonate ions, using experimental methods; and Calculate mass proportions of chemical elements in compounds and solutions; and stoichiometry.
Use acquired knowledge and skills in practical activities and daily life to	Safely use substances and materials, develop ecologically literate behavior with regard to the environment; evaluate the influence of chemical pollution of the environment on humans; and critically evaluate substances used in everyday life and make solutions of a given concentration.

Similar to the new standards for primary education, the new 2011 Federal State Education Standards for Basic Education emphasize the importance of meta-cognitive skills and personal development as well as the acquisition of basic content knowledge and skills when learning school subjects, doing projects, and participating in extra-curricular activities related to science education. The new standards make the science education environment in basic school more open to and reflective of student interests and abilities.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

The school year in primary education (Grades 1–4) is 33 weeks, with class periods ranging from 35–45 minutes. In basic education (Grades 5–9), the year is 35 weeks, and class periods are 45 minutes.

According to the national curriculum for general education, mathematics and science are compulsory subjects. Mathematics is taught four times a week in primary education (Grades 1–4) and five times a week in basic education (Grades 5–9). In primary education, science is taught two times per week for four years. In basic education, science is taught as an integrated subject in Grade 5 (two classes per week); in Grade 6, as two separate science subjects—biology and geography—with two classes per week for each subject; in Grade 7, as three separate subjects—biology, geography, and physics—with two classes per week for each subject; and in Grades 8 and 9, as four subjects—biology, geography, physics, and chemistry—with two classes per week for each subject.

The national curriculum, in addition to the federal component, includes a regional component, where about 10 percent of instructional time may be spent on different subjects, including mathematics and science, according to regional priorities. This additional time allows students to learn more about the nature of their regions, and teachers have the opportunity to be involved in activities to develop instructional materials using the regional context.

Instructional Materials, Equipment, and Laboratories

Decisions about the organization of the learning process and its provision (i.e., materials, textbooks, and equipment) are made at the school level in accordance with federal and regional norms and requirements. Textbooks are chosen from the federal list of recommended textbooks, which are approved by specialists from the Russian Academy of Sciences and the Russian Academy of Education.

Improving the experimental and practical skills of students, as well as the application of mathematics and science knowledge in everyday life, is directly connected with the quality of equipment at schools. In recent years (2005–08), various national projects aimed at better equipping schools, especially with science laboratories, have partially improved the situation. However, shortages of school materials and equipment continue to present a problem in schools, especially in rural areas.

Use of Technology

In the last decade, Russia introduced information and communication technology (ICT) into general education. Federal and regional projects, such as the Development of Common Educational Information Environment, Electronic Russia, and the Informatization of the Educational System, aim to develop a technology infrastructure and electronic educational resources, provide professional development for teachers in technology, and introduce ICT into the learning process and school management. These activities have produced, among other results, a national Internet portal, electronic textbooks, and a nationally distributed electronic library of information resources. Consequently, all schools in Russia now have ICT for use in the classroom and Internet access.

Because of the introduction of the new 2009 standards, the role of ICT is changing considerably from a means of communication and obtaining information to a means of learning and personal development. Standards define three levels of requirement for using ICT in general education: ICT in the curriculum and school resources, real teacher practice, and student achievement in ICT use in learning.

ICT educational resources that have been developed for schools may be divided into three groups, according to their use in the learning process. The first group includes resources that can be used in all subjects, including interactive boards, illustrations, word or graph-processors, discussion boards, and concept maps. The second group includes resources developed specially for specific subjects, such as virtual physics or chemistry laboratories, or mathematics models (e.g., geometry constructors). The last group includes electronic measuring devices, such as sensors or digitizers, which can be used for direct or indirect measurements or observations in science (e.g., illuminance sensors or electronic microscopes).

Grades at Which Students Specialist Teachers for Mathematics and Science are Introduced

The majority of students in Russia have specialist teachers for mathematics and science for the first time starting in Grade 5 in basic education.

Homework Policies

Traditionally, homework is assigned for each lesson throughout primary and basic education. In practice, in Grade 4, teachers assign mathematics and science homework for 15–30 minutes and in Grade 8, for 30 minutes on average.

Teachers and Teacher Education

Teacher Education Specific to Mathematics and Science

There are several different ways to become a primary or secondary education teacher. Teacher education for the primary education level (Grades 1–4) may include five years of formal education at a higher education institution with specialization in pedagogy, methodology, and primary education instruction. Alternately, education may include four years of a bachelor's program at a higher education institution with specialization in pedagogy, two years at a pedagogical college having entered the college following graduation from secondary school, or four years at a pedagogical college, having entered college following graduation from basic school. In recent years, earning a diploma from a higher education institution has become more widespread among primary school teacher candidates.

Teacher education for mathematics and science at the basic and secondary education levels (Grades 5–11) also may include the following: five years of formal education at a higher education institution with qualifications as a teacher of mathematics, physics, chemistry, biology, or some combination of these; four years of higher education, with a Bachelor of Physics-Mathematics (or Science) Education; or six years of higher education with the qualification of Master of Physics-Mathematics (or Science) Education. A student must complete the education program in accordance with the national educational standards of higher professional education, prepare and defend his or her graduate qualification work, and pass the national examinations.

Requirements for Ongoing Professional Development

Professional development is no longer compulsory and is changing its orientation to align with new education goals. This realignment involves a change in emphasis from subject content to student development, so that teachers have more training in active learning strategies and child development. Teachers also are taught to use ICT in the learning process.

Monitoring Student Progress in Mathematics and Science

National or Regional Examinations

The general education system has a very flexible system of school examinations. To be awarded the basic school certificate, students must pass four examinations: compulsory national examinations in mathematics and Russian and two examinations in subjects selected by the students themselves. To be awarded the certificate of secondary school completion, students must pass two compulsory national examinations in mathematics and Russian. Examinations in science subjects are not compulsory, though at Grades 9 and 11, students may choose to take an examination in any science subject. These examinations are prepared centrally by the test developers from the Federal Institute of Educational Measurement.

Standardized national examinations, known as Unified State Examinations, have been introduced since 2009, combining the general secondary education graduate examinations with higher education entrance examinations.

In addition to the national examinations, a school may set examinations on every subject at any grade of basic or secondary education, which may be administered in oral or written form and include multiple-choice and short- or extended-response questions and essays.

Introduction of national educational standards has changed the procedure for school accreditation, increased the role of student assessment, and slightly changed the emphasis from assessment of separate science subject knowledge to assessment of scientific literacy and the nature of science knowledge and skills.

With the aim of looking for talented students interested in mathematics and science, more Olympiads and other competitions have been organized. In the last decade, more attention has been focused on project and investigation results, with an integrative nature, than on subject knowledge acquired.

Monitoring Individual Student Progress

Schools administer formative and summative assessments to ensure compliance of student achievement with the curriculum requirements and to diagnose student progress, and schools also choose the timing and form of these assessments. Assessment results sometimes are used for teacher or school accreditation. Generally, summative assessment takes place at the end of each school year in each school subject. Assessment formats include oral examinations, short-answer, extended-response or essay questions, and multiple-choice tests. Schools usually use individual teacher-made tests, locally developed tests, or tests developed centrally and published as special supplementary materials.

Innovations in assessment arising from general education reform include the introduction of a qualitative system of assessment without grades or marks in primary school and a shift in the orientation of assessment from absolute achievement to the dynamics of student achievement throughout primary school.

Impact and Use of TIMSS

The Russian Federation's participation in IEA studies is considered an important benchmark in evaluating the quality of education in the country. Since 2005, the country's participation in international studies has been stipulated in the Federal Program of the Education Development adopted by the State Duma and financed through the federal budget.

During the last five years, the use of TIMSS data has intensified. More and more specialists in different areas have started to use the data and initiated secondary analyses. Specifically, TIMSS data has been used for the following:

- Informing different audiences (e.g., policy-makers, teachers, researchers, and students).
- Explaining results and planning new studies (e.g., using secondary analysis of TIMSS data).
- Developing new state educational standards for primary (in 2009) and basic education (in 2011).
- Training specialists in educational measurement and data analysis at the federal and regional levels.
- Developing new master's degree programs in educational measurement and evaluation, the curricula of which now include the course, International Comparative Studies in Evaluation of the Quality of Education. Students work with TIMSS datasets and conduct data analyses. In 2011, five students participated in IEA-ETS Spring Academy;
- Using TIMSS data and results in joint projects with other countries. For example, Russian specialists worked with Tajikistan mathematicians in a project supported by the READ Russia-WB CICED small grant program, Secondary Analysis of TIMSS-2007 Mathematics Results to Develop Recommendations to Improve Mathematics Learning in Primary and Basic School.

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Saudi Arabia

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Introduction

Overview of the Education System[1]

The Kingdom of Saudi Arabia believes that it is essential to prepare good and productive citizens who can meet the needs of this era and the future. To this end, the government considers investment in education and human resources to be a basic element in the comprehensive development of the country and the advancement of its policies and programs.

Since the founding of the nation in 1932, the public education system in Saudi Arabia has accomplished the following:

- Free education available to all throughout the country;
- Near complete (99%) enrollment of targeted children in primary education;
- Educational opportunities equally available to men and women; and
- A radical decrease in illiteracy among men and women.

In addition to these, other achievements related to developing curricula and adopting student evaluation policies have focused on satisfying basic needs, providing and developing the learning environment, and improving procedures for hiring and integrating teachers and for reviewing teachers' employment status.

The Ministry of Education administers the education system in Saudi Arabia and currently aims to achieve the following:

- Differentiate teaching for all students, based on individual abilities, by placing students at the center of the education process;
- Plan and direct the learning process by developing standards and requirements and new systems of quality control and motivation;
- Avoid centralization in managing learning processes by granting independence to both educational directorates and schools;

- Provide facilities and equipment to schools, and focus school plans and programs on learning processes; and
- Build capabilities, human and technical, to manage education; lead the process of developing schools and achieving quality performance; grant suitable administrative authority; define goals for students; and establish schools that can accomplish these goals.

The ministry oversees educational directorates and has refined their missions and processes to help schools concentrate on student learning and commit to nurturing personal development. This refinement also has put in place mechanisms to aid directorates and schools in meeting learning outcomes and organizing supervision. Currently, school and directorate competence is assessed according to administrative effectiveness, ability to implement education, and effective follow up and monitoring. The Educational Department Council and its secretariat develop plans for courses of study and requisite educational infrastructure; approve plans and policies for educational development, training, educational research, computer projects, learning technology, and assessment; develop curricula; and prepare teacher education and professional development programs. The Ministry of Education supervises these plans via its educational directorates and offices in all parts of the country.

General education in Saudi Arabia is divided into public (government-funded) education, private education, special education (under the supervision of the ministry), vocational education (related to the Technical and Vocational Training Corporation), and foreign education. There are also many specialized institutes under the supervision of different departments, such as the Ministry of Health and telecommunications and security departments. There are 30 universities (six of which are private) in addition to many colleges offering varied courses of study. Basic compulsory education in Saudi Arabia is for all children ages 6–15. Saudi Arabia's public education system is organized according to the following structure:

- Primary education—This level is six years and covers Grades 1–6.
- Intermediate education—This level is three years and covers Grades 7–9.
- Secondary education—This level is three years and covers Grades 10–12.

Languages of Instruction

The official language of the country and education is Arabic.

Mathematics Curriculum in Primary and Lower Secondary Grades

The authorized mathematics curriculum in Saudi Arabia is similar to curricula published by McGraw Hill. These curricula are based upon a balanced merging of learning and rely on vertical interdependence to develop cognitive understanding and mathematical skills for all grades. Specifically, this approach depends upon the following:

- Examining concepts and building cognitive skills;
- Developing mathematical skills and the ways of mastering them; and
- Applying mathematics logically to solve problems from daily life.

In the fourth grade of primary education (Grade 4), mathematics textbooks cover five domains—number, algebra, measurement, geometry, and statistics—and content discussed within theses domains includes the following:

- Number—Whole numbers and comparisons of whole numbers; place values up to one million; the concept of fraction; equivalent fractions (comparing, ordering, and placing them on the number line); and categorizing fractions (rational, irrational, and decimal).
- Algebra—Defining and explaining patterns of multiplication and division; properties of addition and multiplication; basics of subtraction and division; and algebraic representations of number sentences.
- Measurement—Units of length, area, volume, and mass; time intervals; and perimeters and areas of squares.
- Geometry—Categorizing and describing solids; geometric concepts about lines (e.g., parallelism and perpendicularity); angles and types of angles; polygons (e.g., triangles and congruence); and placing numbers and fractions on the number line and in the coordinate plane.
- Statistics—Collecting and categorizing data; creating bar graphs; reading and explaining data; and finding median and mode.

In the second grade of intermediate education (Grade 8), mathematics textbooks cover five similar domains—number, algebra, measurement, geometry, and statistics and probabilities. Content discussed includes the following:

- Number—Proportionality; rate of change; scale; percentage and its applications; whole numbers, integers, and rational and irrational numbers; and square roots.

- Algebra—Arithmetic progression; simplifying algebraic expressions; algebraic transformations; solving linear equations and inequalities; functions and their applications; and slope.
- Measurement—Perimeter and area of a circle; and surface area and volume of prisms, pyramids, and cylinders.
- Geometry—The Pythagorean theorem; identification of polygons; the relationship between lines and angles; plotting points on the coordinate plane and the distance between two points in the plane; and geometric transformations of figures (e.g., symmetry across a line or around a point, translations, and scale changes).
- Statistics and Probabilities—Histograms; pie charts; data presentation; measures of central tendency; range; and measures of dispersion.

Science Curriculum in Primary and Lower Secondary Grades

The officially authorized science curriculum in Saudi Arabia is organized around texts designed to position the student centrally in the teaching and learning process. Various activities are designed for recursive learning and allow students to participate at all levels. The overall philosophy of science textbooks emphasizes the importance of the scientific method of investigation, practical skills (e.g., scientific reading and writing, drawing, and collecting samples), and connecting science knowledge with daily life (e.g., relating science to mathematics and society).

At the fourth grade of primary education (Grade 4), science textbooks include the following topics:

- Living creatures, cells, classification, plants, animals (vertebrates and mollusks), and animal conservation;
- Environmental systems;
- Earth, water, and minerals;
- Space and the solar system;
- Substances and their changes; and
- Power and energy.

In the second grade of intermediate education (Grade 8), science textbooks include the following topics:

- Life, cell activities, and genetics;
- The human body; the immune, digestive, and respiratory systems; and bodily motion;
- Relation between living organisms; and
- Energy and substances.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Materials, Equipment, and Laboratories

Mathematics labs, visual aids, and computer labs are found in most of the Kingdom's schools. There are also supplemental materials, such as geometric figures, teaching aids, and illustrated textbooks with accompanying exercise books. In addition, there are guidebooks, teacher's manuals, flash cards, posters, and computer software specifically prepared for teachers.

Use of Technology

There are no policies for calculator or computer use at the fourth grade of primary education (Grade 4). In the second grade of intermediate education (Grade 8), calculators may be used to assist students in understanding specific skills. Computers also are used at this grade, and students are sometimes asked to visit certain Internet sites or links. Computer use as a formal subject is introduced in Grade 7 in public schools, but is practiced as an extracurricular activity in all grades. In private schools, computer use starts as a formal subject in Grade 1.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

All teachers of the first grade in intermediate education (Grade 7) and beyond are specialized in mathematics and science, as are most fourth-grade primary education teachers. Some teachers who are well qualified, have considerable teaching experience, and have participated in a significant amount of professional development courses are allowed to teach mathematics and science provisionally, even if they do not have a minor degree in these subjects. In the future, these teachers gradually will be replaced by academically qualified specialist degree holders.

Homework Policies

There is no official policy regarding homework. Guidelines differ based on many factors, including the type of school (public vs. private) and the school district.

Teachers and Teacher Education

The Ministry of Education guarantees certain teacher rights, some of which require the ministry to develop teacher job performance levels, secure teaching positions for those with contract renewals, and equally and fairly assign and transfer teachers. Teachers also have the right to study or practice abroad, and to present their needs and ideas through a number of teacher consultative councils. Currently, the ministry is planning a new recommendation system that will encourage teachers to improve their performance. In addition, the ministry is planning to implement a new system for teacher licensure to clarify the status of teacher positions and also to ensure improvements in teacher performance.

During the present teacher recruitment process, university graduates from every discipline are screened. Regardless of the level they intend to teach, prospective teachers are required to meet the following requirements:

- Hold a bachelor's degree in a teaching major;
- Pass a proficiency test in their major and a test of general educational proficiency;
- Pass a medical examination; and
- Pass a background interview that assesses the candidate's personality and character.

The Ministry of Education seeks to develop qualified teachers by helping those with teaching diplomas complete their studies and obtain bachelor's degrees in their disciplines. Currently, the ministry is planning a new program, Preparing and Training Teachers, to educate approximately 15,000 new male and female teachers throughout the year. Specifically, the program aims to aims to accomplish the following:

- Build a comprehensive system for preparing new teachers;
- Build positive trends and enhance loyalty to teaching;
- Qualify new teachers and enrich their performance through education;
- Make teachers aware of the educational environment and its various systems; and
- Guarantee a specific level of job performance.

The Ministry of Education cooperates with the National Center for Assessment in Higher Education (*Qiyas*) to develop general teaching standards in all teaching disciplines and to determine whether new teachers have met these standards. The Ministry of Education also collaborates with the Ministry of Higher Education to develop additional standards for new teachers, and some of these efforts include the following:

- Preparing standards for general teacher education levels in cooperation with Colleges of Education and Teachers' Colleges, guided by the international standards applied to every subject for all levels of the general curriculum;
- Preparing professional development programs for teachers based on education and professional standards; and
- Reviewing the courses of study of Colleges of Education and Teachers' Colleges to ensure they meet the requirements of the new curricula.

Apart from collaborating with the Ministry of Education, the Ministry of Higher Education is charged with the following missions:

- Ensuring that Colleges of Education and Teachers' Colleges are able to fulfill the Kingdom's future needs for teachers in all fields;
- Coordinating with international recommendation committees to develop a set of recommendations for educational colleges nationally and internationally, and urging universities to fulfill academic recommendations; and
- Developing the Colleges of Education and Teachers' Colleges, using best standards and practices and through cooperation with distinguished international colleges and universities.

Requirements for Ongoing Professional Development

The Ministry of Education sends some teachers and administrators to national universities or abroad to obtain master's or doctoral degrees. The ministry further seeks to train qualified teachers with extensive professional development courses and programs throughout the year to enhance teacher performance, according to the needs of curricular projects, some of which are developed in cooperation with specialized private sector corporations.

Teachers receive professional development and supervision throughout their careers through a number of means. For example, computerized supervision allows for rapid idea exchange and information access that helps to develop teacher knowledge, teaching environments, and quality teaching outputs. Presently, the ministry is launching an electronic gateway for communication within the education sector to contribute to knowledge building and assist teachers in publishing educational research. Additionally, a new project known as Teach Me How to Learn aims to develop teaching strategies and techniques for use in and out of the classroom.

The ministry also is preparing a project for teacher assessment to improve practical and educational outputs to build knowledge. Another program aims to implement changes to educational programs based on analyses of teacher evaluations and educational trends.

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Serbia

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Introduction

Overview of the Education System

In the Republic of Serbia, the Ministry of Education and Science provides centralized oversight and management of education.[1] Decentralization of education began in 2000, when schools were given greater pedagogical, administrative, and financial autonomy. In practice, however, schools still are limited by centralized regulations and policies—local governments have assumed a greater role in managing education, and educational funding remains largely centralized.[2] Further decentralization of education in Serbia is currently the subject of national debate.[3]

The Ministry of Education and Science is organized into regional units called the school authorities and performs the following functions: research, planning, and development; supervision of education professionals and pedagogy; and organization, evaluation, and supervision of professional development.[4, 5] Within the ministry, the Institutes for Education Quality and Evaluation and for Education Improvement are responsible for implementing consulting, research, and development in education at the national level. The National Education Council approves curricula and proposes final and Matura examinations, textbooks, and teaching aids to the ministry. The national curricula determine the number of classes per subject, teaching goals and objectives, and the content of each subject for each grade, in addition to providing detailed instructions for teachers to follow when teaching the subject. The curricula are used as a basis for evaluating education in schools.[6]

The Serbian education system encompasses six ISCED levels: preschool education (ISCED level 0); first cycle of primary education (ISCED level 1); second cycle of primary education (ISCED level 2); secondary education

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(ISCED level 3); specialized vocational, undergraduate, and graduate studies (ISCED level 5); and doctoral education (ISCED level 6).[7]

Preschool education takes place in nurseries (for children ages 1–3) and kindergartens (for children ages 3–7). Preschool is guided by the unique basic principles of the preschool curriculum. Beginning in 2006–07, a preparatory preschool program was introduced, which is nine months long and is obligatory for children ages 6½–7½, as a part of a nine-year program of compulsory education.

Primary education is free and compulsory, and lasts eight years. There are two educational cycles in primary schools: general classroom teaching, from first to fourth grade (the first cycle of primary education); and subject teaching, from fifth to eighth grade (the second cycle of primary education). A child who is at least 6½ but not older than 7½ years old at the beginning of the school year can enroll in the first grade. After completing the eighth grade, students take a final examination; enrollment in secondary school does not depend on passing the examination, although passing is required for entrance to specialized secondary schools and art schools.[8]

Secondary education takes place in secondary schools, which include general high schools (gymnasia), vocational schools, art schools, adult education schools, and schools for students with disabilities. Secondary education is free for both regular and part-time students in public schools and lasts three or four years (Grades 9–11 or 12). After completing the fourth year of secondary school (Grade 12), students take the *Matura* examination, which is used to determine eligibility to enroll in higher education.

Higher education covers basic and specialized vocational studies (three and two years, respectively), as well as undergraduate, graduate, and specialized academic studies (a total of five years). At state universities, education is free for a specified number of students; additional students wishing to enroll beyond this initial quota may pay tuition fees. Higher education policies are proposed by the National Education Council for Higher Education, and freedom of academic activities in higher education and university autonomy are guaranteed by law.[9]

Doctoral studies last three years and prepare students for independent scientific research. Students are charged tuition fees for doctoral studies.

Languages of Instruction

The official language in the Republic of Serbia is Serbian and the official alphabet is Cyrillic, although the Latin alphabet also is used. In some areas inhabited by ethnic minorities, both the Serbian language and the languages and alphabets of national minorities are used, under certain legal conditions.[10]

Serbian is the language of instruction, although in exceptional cases teaching is bilingual or in a foreign language. For members of ethnic minorities, teaching is provided in their native language if, at the time of enrollment in the first grade, at least 15 pupils of that minority concurrently enroll (although in some cases, native-language teaching can be implemented for a smaller number of students).[11] Minority languages in Serbia are Albanian, Bosnian, Bulgarian, Wallachian, Hungarian, Macedonian, German, Romany, Romanian, Ruthenian, Slovak, Ukrainian, Croatian, and Czech.[12] During the 2009–10 school year, primary school instruction was offered in Albanian, Bulgarian, Hungarian, Romanian, Ruthenian, Slovak, and Croatian.[13]

Mathematics Curriculum in Primary and Lower Secondary Grades

The goals of the mathematics curriculum in primary school include the following:

- Providing students with basic mathematical knowledge and the ability to apply that knowledge to solve problems in everyday life;
- Laying a foundation for continuing students' mathematical education and self-education; and
- Developing students' mental abilities and their ability to form a scientific view of the world, as well as the overall development of their personality.

The curriculum for mathematics prescribes teaching objectives and specifies operational tasks for every grade. The curriculum describes the mathematical knowledge and skills that students should master at the end of each grade in primary school. Educational standards for mathematics at the end of the first and second cycles of primary education contribute to defining successful teaching.

Standards for achievement in mathematics at the end of the first cycle of education are specified at three levels (basic, intermediate, and advanced) for the following areas: Numbers and Operations, Geometry, Fractions, and Measuring and Measurements.[14] The mathematics curriculum in the second cycle of education is structured similarly to the curriculum for the first cycle, but also includes an additional chapter orienting teachers to programs for additional work with students. Standards for achievement in mathematics at the end of the second cycle of compulsory education are specified at three levels (basic, intermediate, and advanced) for each of the following areas: Numbers and Numerical Operations, Algebra and Functions, Geometry, and Measuring and Data Analysis.[15]

Exhibit 1 presents the mathematics capabilities students are expected to have achieved from the first through the eighth grade.

Exhibit 1: Mathematics Curriculum, Grades 1–8

Grade Level	Capabilities
Grades 1–4[16, 17, 18]	Understand natural numbers including zero;
	Perform operations with natural numbers and understand numerical expressions including equations and inequalities;
	Identify and measure geometric shapes;
	Understand the metric system, measure objects in the environment, and understand the relationship between familiar units of measurement;
	Solve word problems with increasing levels of complexity; and
	Use mathematical language, including basic symbols, expressions and formulas.
Grade 5[19]	Create and graphically display sets and their subsets; perform operations related to sets; understand the meaning of “and,” “or,” “no,” “every,” and “some” in mathematical contexts; and recognize familiar geometric objects (e.g., lines, line segments, rays, planes, circles, and angles);
	Understand the properties of angles formed by parallel lines and a transversal, and angles formed in figures with parallel sides;
	Draw a line parallel to a given line;
	Understand the basic rules of divisibility and how to divide natural numbers;
	Determine the least common multiple and greatest common factor;
	Understand the concept of fractions, know how to write fractions in different ways, convert fractions from one mode to another, compare fractions, and present them on the number line;
	Read, compose, and calculate simple numerical expressions;
	Solve simple equations and inequalities with fractions;
	Recognize mathematical content in text and express it in mathematical language;
	Understand axial symmetry and its properties;
	Identify the center of a line segment; and
	Construct angle bisectors and a line perpendicular to another line through a given point.
Grade 6[20]	Understand negative numbers, the structure of the sets of integers and rational numbers, and the absolute values of numbers;
	Perform basic arithmetic operations with integers and rational numbers;
	Read simple expressions containing rational numbers and calculate their numerical values;
	Solve simple equations and inequalities on the set of rational numbers;
	Express percentages and use them in practice; classify triangles and rectangles and know their basic properties; and understand congruence and its properties, and know how to apply it when constructing triangles and rectangles;

Grade Level	Capabilities
Grade 6	Calculate the area of triangles, parallelograms, and rectangles;
	Apply rules for calculating the areas of triangles and rectangles in a variety of practical tasks;
	Use deductive reasoning (e.g., correctly defining statements; and properly using the words "and," "or," and especially "if…then…" and "if and only if…"); and
	Understand the need for presenting evidence in proofs and know how to do so in simple cases.
Grade 7[21]	Understand the concepts of squaring and finding square roots of rational numbers;
	Find the approximate value of the square root of a rational number;
	Understand the concept of exponentiation and operations with natural-number exponents;
	Perform basic arithmetic operations with polynomials;
	Understand the rectangular coordinate system and its application;
	Understand direct and inverse proportionality and its practical application;
	Understand the Pythagorean theorem and how to apply it to geometric figures that contain a right triangle;
	Recognize the most important properties of polygons and circles;
	Construct regular polygons with three, four, six, eight, and twelve sides and draw other regular polygons;
	Recognize a central angle and draw it using a protractor; and understand the most important properties of polygons and circles and apply them in problems;
	Understand the concepts of scale and proportion;
	Translate word problems into mathematical language and solve them; and
	Use elements of deductive reasoning in simple proofs.
Grade 8[22]	Solve linear equations (including inequalities) and systems of linear equations in one or two unknowns and interpret the solution graphically;
	Represent word problems using appropriate mathematical language and solve them;
	Identify functional dependencies and display them in different ways;
	Understand the concept of function and graphical representations of functions;
	Understand linear functions and their properties;
	Draw and interpret linear functions;
	Interpret data presented in graphs and tables;
	Construct a table and draw appropriate graphs and diagrams from the data;
	Calculate the median of a data set;
	Understand the relationships between points, lines, and planes in space;
	Understand projections in a plane and the elements and properties of solid figures (e.g., prism, pyramid, cylinder, cone, and sphere);
	Calculate the surface area and volume of a solid figure;
	Apply knowledge of solid figures in practice, linking the content of mathematics and other areas; and
	Apply elements of deductive reasoning in proofs.

Science Curriculum in Primary and Lower Secondary Grades

Primary school students become familiar with science content in several subjects beginning in first grade and continuing through the end of primary school.

In the first cycle of basic education (Grades 1–4), students study science in the compulsory subjects The World around Us (Grades 1–2) and Nature and Society (Grades 3–4).[23] Students also may choose to take the optional subject Nature Protectors.

As a school subject, Nature and Society can be connected to other components of basic education at all levels within the subject, between subjects, within the grade, and between grades. Nature and Society provides younger students opportunities to develop competence in content from various natural and social sciences. The main goals of this subject are to help students understand phenomena that they know from everyday life and to lay the foundation for understanding abstract concepts and scientific opinion. The curricular concept of using upward spiraling to build concepts, knowledge, skills, attitudes, and values in the area of nature and society is applied when selecting age-appropriate content for the curriculum. The structure of the Nature and Society curriculum in the third and fourth grade (i.e., aims and objectives, content selection, and methods of curriculum implementation) clearly indicates the continuity of increased development of competence in the field of natural sciences.

An innovation in the educational system of Serbia in the field of natural science in the first cycle of primary education (Grades 1–4) is the introduction of educational standards for Nature and Society. General standards of achievement are provided at three levels (basic, intermediate, and advanced) for the following areas: Living and Non-living Nature, Ecology, Materials, Motion and Orientation in Space and Time, and Society and the Republic of Serbia and Its Past. Key competencies in this subject take into account the science content and the intellectual capabilities and limitations of early school age students (and the influence of these capabilities on pedagogy in teaching science content).[24]

Science content for the second cycle of primary education (Grades 5–8) is taught in the compulsory subjects of biology, geography, physics, and chemistry, as well an optional subject called Nature Protectors, which is offered to students in the fifth and sixth grades. Biology and geography are taught during the entire second cycle, while physics is taught in the sixth, seventh, and eighth grade, and chemistry in seventh and eighth grade. The structure of the curricula for these subjects is similar and includes subject area aims and objectives, teaching aims and objectives that are concretized as specified operational tasks for each grade, and curriculum implementation methods. In addition, the chemistry curriculum also includes a chapter orienting teachers to programs of additional work with students.

The main goals of the science subject curricula in the second cycle of primary education are as follows:

- Biology—Education in biology should ensure that students learn the basic concepts of the living world, its historical development, natural phenomena, and the laws of nature. According to the biology curriculum, students should be able to do the following at the end of the eighth grade: understand the role and importance of biology in the progress of mankind and to sustainable development; understand the gradual evolution of wildlife; understand that living things are classified into five kingdoms based on similar characteristics; know about the structure and function of living organisms; develop the ability to relate concepts and processes in living organisms and nature; know about the diversity and distribution of living organisms; understand the relationships between living things and the environment, as well as the dynamics of the circulation of matter and energy flow; develop a sense of responsibility for the state of the environment; understand threats to the biosphere and the role of each individual in its protection and improvement; know the structures and functions of the human body systems; gain the necessary hygiene habits to preserve their own health and the health of others; realize that sexuality is an integral part of life and respect the norms of behavior between people; use methods of observation, measurement, and experimentation; and have a clear idea of occupations related to biology when choosing a future profession.

- Geography—Education in geography should ensure that students gain knowledge about phenomena and processes and their relations in geo-space. One of the goals of the geography curriculum is for students to gain knowledge and develop skills and opinions in geography and apply these in everyday life. According to the curriculum, students should learn about the following: basic objects, phenomena, and processes in the universe; the Earth's surface and environments; and basic geographical features of Europe, the other six continents, and the Republic of Serbia. Students also should understand the Earth's structure and causes and effects of phenomena and processes. The geography curriculum also contributes to developing students' views about the protection and improvement of the environment. Cartography content has great educational importance within geography because it forms the basis for understanding all aspects of geography and has general educational importance because of the necessity to use maps in almost all fields of human activities.

- Physics—Education in physics should ensure that students gain basic linguistic and scientific literacy and progress towards implementing appropriate standards of educational achievement. Implementation of the physics curriculum takes into account three facts: that abstract thinking ability is not yet completely developed in primary school students, that physics is an abstract, accurate and diversified scientific discipline, and that experiments are unjustly neglected in teaching physics. Physics teaching goals include accomplishing the following by the end of the eighth grade: introducing basic ways of thinking and reasoning in physics; understanding phenomena, processes, and relationships in nature based on physical laws; developing the ability to actively gain knowledge about physical phenomena through investigation; encouraging curiosity, rational thinking, independence, and critical thinking; developing skills of clear and precise expression; developing logical and abstract thinking; understanding the meaning and methods of implementing experiments and the importance of measuring; solving simple physics problems; developing the ability to apply physics knowledge; identifying and understanding the relationship between physical phenomena and ecology; developing awareness of the need for environment protection, restoration, and improvement; developing work habits and preferences conducive to studying natural sciences; and developing awareness of one's own knowledge, skills, and further professional orientation.

- Chemistry—Education in chemistry should ensure that students gain scientific literacy, functional chemical literacy, and progress towards implementing appropriate standards of educational achievement. The seventh grade chemistry curriculum covers basic concepts of general chemistry and the eighth grade curriculum covers inorganic and organic chemistry. At the seventh grade, the curriculum is arranged in five topics: the development of chemistry as a science and its role in contemporary life; basic chemical concepts; solutions, solubility, and quantitative expressions of solution composition; connecting chemistry concepts to everyday life; and chemical changes and quantitative aspects of chemical reactions. At the eighth grade, the curriculum is arranged in six topics: characteristics of non-metals and metals; salts and ionic compounds; the properties of acids and bases and electrolytic dissociation; the basic characteristics of organic compounds and how they differ from inorganic compounds; the physical and chemical characteristics of some organic compounds (e.g., hydrocarbons, alcohols, carboxylic acids, and esters), including the biologically important compounds; and the causes of environmental pollution and procedures to minimize the consequences of their impact.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Materials, Equipment, and Laboratories

Although there is a problem of inadequate equipment in schools in Serbia as a consequence of an unfavorable economic situation, there is a significant national effort to equip schools with computers (e.g., the Digital School program), teaching aids, equipment, laboratories and other equipment.[25, 26, 27]

The Regulations on Quality Standards of Educational Institutions are used as the basis for self-evaluation and external evaluation of Serbian schools.[28] Two standards regarding resources specifically relate to school educational materials and technical equipment, and appropriate indicators are defined in order to evaluate whether schools provide these materials and resources, and whether these are used effectively to achieve quality in education.

Many textbooks from different publishers are available to teachers and students in Serbia. Textbooks used in schools must be chosen from the list of textbooks approved by the Ministry of Education and Science. Teacher councils decide which textbooks will be used in a particular school, based on recommendations from professional councils in subject fields or classroom teaching.[29] In 2009, the Ministry of Education and Science implemented a program to provide textbooks free to schools.

Use of Technology

The mathematics and science curricula do not prescribe or provide guidance on using computers in teaching mathematics and science. Students use computers in school, but rarely in mathematics and science.[30]

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Science subjects are taught by general classroom teachers in the first cycle of basic education (Grades 1–4), but science subjects in the second cycle (Grades 5–8) are taught by specialists in biology, geography, physics, or chemistry.

Homework Polices

Homework requirements are defined only in the curricula for mathematics for Grades 1–4 and in physics. In mathematics, homework assignments are an integral part of the written lesson plan and are planned in accordance with content and students' abilities. Homework assignments in physics involve working with students on each lesson's material and connecting it to material covered previously. Teachers plan homework when preparing for the class, pay attention to the selection of tasks, and assign only tasks which students can solve without assistance. Although not specified in the curricula, in practice, homework also is assigned in other science subjects.

Teachers and Teacher Education

Preschool is taught by preschool teachers, preschool teacher-nurses, and special educators. Preschool teachers have completed three years of basic college education, undergraduate, and graduate or professional studies.[31]

Teachers in the first and second cycles of education (Grades 1–8) must have a second degree in education (graduate academic or specialist studies), depending on the type of school where they work and the subject they teach. The teacher also must be educated at a higher education institution in psychology, pedagogy, and methodology.[32]

There are differences in the education of general classroom teachers in the first cycle of primary education (Grades 1–4) and subject teachers in the second cycle of primary education (Grades 5–8) and in secondary schools. General classroom teachers are trained at university-level teacher education faculties. The curriculum contains a large number of pedagogical and psychological subjects and special methods of teaching for all subjects in the first through the fourth grade. In their initial education, teachers study mathematics and nature as well as the subjects Teaching Mathematics and Teaching Nature and Society.

Subject teachers are educated in their subject of specialization as well as in pedagogy.[33] Some university departments have teacher education programs included in the curriculum, though some do not. Subject teachers often begin teaching without any formal education in the field of psychology, pedagogy, or teaching methodology. Mathematics, geography, chemistry, physics, and biology teachers do gain some knowledge in pedagogical psychology, general pedagogy, didactics, and methodology for their relevant subject during the course of their studies at universities, but building an effective national system of initial teacher education is a task for future development of education in Serbia.[34, 35]

Teacher professional development is a right and a legal obligation. In order to maintain a teaching license, within five years teachers must complete 100 hours of professional development in accredited training seminars, which are financed primarily by the ministry or local communities. Individual school authorities create professional development plans and coordinate this development for the institution's teachers. Other forms of professional development include congresses, symposia, and conferences.[36]

Monitoring Student Progress in Mathematics and Science

An innovation in the educational system of Serbia is a final written examination taken by all students who have completed the eighth grade. In the 2010–11 school year, this examination was first implemented to assess Serbian language and mathematics. The Institute for Education Quality and Evaluation prepared the examinations and performed a quantitative and qualitative analysis of the results, providing reports for different levels of users: students, classes, schools, municipalities, counties, school authorities and the nation. By the 2013–14 school year, this examination will be implemented in its revised, final form, and will assess student knowledge and skills in the Serbian language, mathematics, history, geography, biology, physics, and chemistry gained over the eight years of basic education.[37] The final examination will be used for student certification, student selection, evaluation and improvement of the educational system, and the self-evaluation and external evaluation of schools.

The Institute for Education Quality and Evaluation also has conducted national testing of third-grade students (2003) and fourth-grade students (2006) in the Serbian language and mathematics. Further, during the drafting of educational standards, eighth-grade students were tested in ten subjects (2005 and 2006) and fourth-grade students were tested in Serbian language, mathematics, and Nature and Society (2005 and 2006).[38, 39] In addition, tests were administered to fourth grade students in Serbian language, mathematics, and Nature and Society (including online testing of fourth-grade students in Nature and Society) for the purpose of school self-evaluation (2009).[40, 41]

In the classroom, teachers assess students based on verbal achievement, written achievement, and practical work, in accordance with the subject syllabus. Depending on the subject and the students' age, the teacher also assesses the following: expression and communication skills; understanding, implementing, and evaluating learned processes and procedures; working with data and working with different types of texts; artistic expression; skill in handling equipment, tools, and technologies; and task performance.[42] Student evaluations are descriptive in the first grade, while in other grades evaluations are numerical: excellent (5), very good (4), good (3), sufficient (2), and insufficient (1).

Impact and Use of TIMSS

Serbia participated in TIMSS in 2003 and 2007 at the eighth grade, following which the Institute for Educational Research conducted a secondary analysis of the results and published them in two separate monographs.[43, 44]

To date, TIMSS has had the following impacts on education in Serbia:

- Education authorities use TIMSS results as an indicator of the effectiveness of the educational system in Serbia and as a basis for decision making to improve the quality of education; specifically, results have indicated that teaching should include more applied knowledge and reasoning, and that some parts of the physics curriculum for the eighth grade should be modified to increase the use of experiments in teaching science;
- TIMSS data about equipment in schools are useful for education authorities in making decisions about future investments;
- The education system has applied the TIMSS experience in the preparation of the final examinations for primary school (e.g., in biology, geography, chemistry, physics, and history);
- TIMSS methodology was used as a model for national testing (and some of the TIMSS released items were used);
- TIMSS cognitive domains are used in Serbian education standards;
- Data from TIMSS serve as the basis for various analyses of the primary education system;[45]
- Researchers use TIMSS data in studying teaching;[46] and
- TIMSS data and tasks are used in teacher education programs.

Suggested Readings

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Singapore

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Introduction

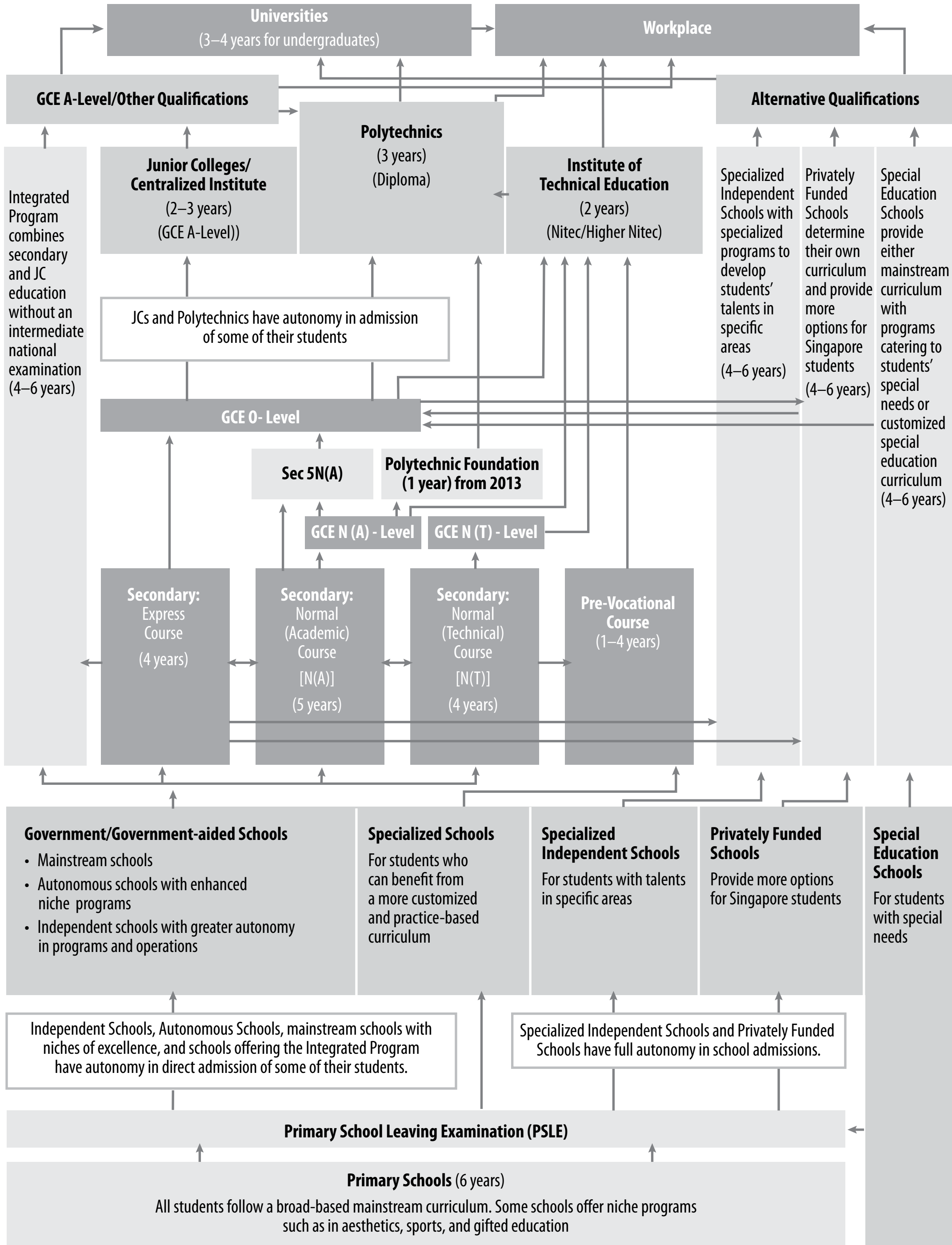
Overview of the Education System

As a small nation with no natural resources, Singapore has always placed a high value on education. The mission of the Ministry of Education is to mold the future of the nation by nurturing the people who will determine the future of the nation. Singapore's education system aims to help every child realize his or her full potential, develop a passion for learning, and be a good citizen, committed to country and community. Virtually all Singaporean students attend publicly funded schools where they receive a broad and holistic education, and are equipped with skills and knowledge to participate effectively and productively in life.[1]

In 1997, the launch of "Thinking Schools, Learning Nation" (TSLN) marked an important milestone in transforming Singapore's education system from one that was efficiency-driven and more centrally controlled to one that is ability-driven and characterized by flexibility, diversity, and greater school autonomy.[2] New education pathways and curricular options have been introduced that recognize different student abilities, learning styles, and interests, and give students flexibility to progress along the most suitable educational pathways to reach their fullest potential. Exhibit 1 illustrates the diversity of pathways, including avenues for lateral transfers between courses of study available to students. TSLN also gives school leaders and teachers greater autonomy to drive change at the local level with financial, policy, and research support from the ministry.

Preschool education is not compulsory in Singapore, but there is a high participation rate (98% for the 2010 Grade 1, or Primary 1, cohort). Preschoolers have access to diverse programs and curricula through private and community-based schools.

Exhibit 1: Education Pathways in Singapore[3]



Primary education is compulsory and formal schooling starts with Grade 1 (Primary 1) at age six. All primary school students are taught a common national curriculum. English (the language of instruction), mother tongue (Malay, Chinese, or Tamil), depending on the ethnicity of the student), and mathematics are emphasized in the primary school years to build a strong foundation in literacy and numeracy. Science is introduced from Grade 3 (Primary 3). The curriculum also includes art, music, civics and moral education, social studies, and physical education, as well as a wide range of co-curricular activities to impart values and build life skills and character.

At the end of Grade 6 (Primary 6), all students take the Primary School Leaving Examination (PSLE), which assesses students in four subjects: English, mother tongue, mathematics, and science. Most students use their PSLE scores to guide their secondary school application decisions. Some students use their achievements in other areas (such as in academic subjects, sports, music, or leadership) to gain direct admission to a secondary school of their choice.

Secondary school education is not compulsory, but is almost universal. In 2009, less than 2 percent of the Grade 1 (Primary 1) cohort[a] did not complete secondary education. At the secondary level, students participate in an Express, Normal (Academic), or Normal (Technical) course of study. The differentiated curricula are designed to match student aptitudes, abilities, and interests. Currently, about 60 percent of students are enrolled in the Express course, about 25 percent in the Normal (Academic) course, and around 15 percent in the Normal (Technical) course. Students can transfer laterally between courses of study. The four- to five-year academic programs lead to the Singapore-Cambridge General Certificate of Education (GCE) Ordinary or Normal Level (O-Level or N-Level) qualifications. Recognizing that students' strengths vary across subjects, students from one course also can take some subjects from a more demanding course; for example, Normal (Technical) students can take Normal (Academic) subjects and Normal (Academic) students can take O-Level subjects from the Express course of study.

Co-curricular activities are an integral part of secondary school education. Depending on their interests, students can choose from a variety of activities ranging from uniformed groups (Boy Scouts, Girl Guides, and Band, etc.) to sports and the arts. Students with special talents in the arts, sports, mathematics, and science, can enroll in specialized independent schools that offer customized curricula to develop these talents. There also are specialized schools that cater to those who would benefit from a more customized and practice-oriented curriculum. Some schools offer the Integrated Program, which combines secondary and pre-university education without an intermediate national examination. Students in these schools experience an enriched curriculum

a The term "cohort" will be used to refer to the "Grade 1 (Primary 1) cohort" in subsequent paragraphs.

and pedagogical approaches that broaden and deepen their thinking skills, leadership, teamwork, and communication skills.

After secondary education, students matriculate to a course of study at a pre-university, the Institute of Technical Education (ITE), or a polytechnic diploma course of study. Approximately 30 percent of a cohort enrolls in the pre-university course of study, offered by a junior college or an Integrated Program school, which prepares students for university education by deepening their knowledge and skill sets. Besides content knowledge, life skills are an integral part of pre-university education. Students are given ample opportunities to engage in activities, both within and beyond the formal curriculum, that help them cultivate important qualities such as initiative, leadership, social responsibility, and strength of character. Students graduate with a Singapore-Cambridge General Certificate of Education (GCE), Advanced Level (A-Level), or an International Baccalaureate (IB) qualification.

About 20 percent of each cohort enrolls in ITE, which offers industry-relevant vocational training that enables 90 percent of its graduates to find employment within six months of graduation. It offers a broad, multi-disciplinary curriculum that ranges from engineering to technical, business, and service skills. ITE students who perform well can progress to polytechnics.

Slightly more than 40 percent of each cohort enrolls in polytechnic education. The five polytechnics in Singapore offer three-year diploma courses in diverse disciplines, such as business, chemical and biological science, communication, design, digital media, engineering, and manufacturing. Polytechnic education is designed around a practice-oriented curriculum that prepares graduates to join industry. Polytechnic students who do well may progress to university.

About 25 percent of students from each cohort enroll in government-funded, autonomous, local universities. Another 20 percent enroll in overseas universities and privately funded local universities. Singapore currently has three autonomous universities: the National University of Singapore, Nanyang Technological University, and Singapore Management University. A fourth university, the Singapore University of Technology and Design, will begin enrolling students in 2012.

Besides the institutions offering full-time courses, part-time skill- and knowledge-building programs for working adults are offered by the continuing education and training sector.

As a technology- and knowledge-based economy, Singapore has always focused on science, technology, engineering, and mathematics. This emphasis on mathematics and science enables Singapore to harness technology and rational policy-making to overcome its constraints as a small open economy with scarce resources. Singapore's education system provides students with a strong foundation in mathematics and science and enables them to pursue and further develop their talents through various programs.

Up to the end of lower secondary, or eighth grade, every student is required to take science; mathematics is a compulsory subject until upper secondary (Grades 9 and 10). At the upper secondary level, students with the inclination and interest have the opportunity to learn deeper mathematics and science concepts by selecting from a wider range of electives. For example, in addition to general mathematics, students can take additional mathematics, which prepares them for advanced mathematics courses at higher educational levels. For science, students can choose to study physics, biology, chemistry, or a combination of these subjects.

Co-curricular activities, such as mathematics and science fairs, competitions, and learning trails (where students apply mathematics and science concepts in outdoor settings) are used to generate interest in the subjects among students. Centers of excellence in mathematics and science also are established at the cluster[b] and zonal[c] levels to provide students with opportunities to enrich their learning experience. At the national level, the DNA Learning Laboratory at the Science Center enriches the teaching and learning of life sciences through hands-on activities for primary and secondary school students.[4] To foster an interest in science, the ministry works closely with the Agency for Science, Technology and Research (A*STAR) and the Science Center to provide opportunities for students to be exposed to research and development under the guidance of scientists and researchers from the various institutes of higher learning and research institutes.[5]

Languages of Instruction

Singapore has a multi-ethnic population with a diverse language environment. There are four official languages: Malay, Chinese (Mandarin), Tamil, and English. Malay is the national language, while English is the language of administration and the language commonly spoken by Singaporeans. The proportion of the resident population age 15 and older who are literate in one or more languages increased from 93 percent in 2000 to 96 percent in 2010.[6]

b A school cluster system comprises twelve to fourteen schools in close geographical proximity, and is overseen by the Cluster Superintendent, an experienced school leader.

c School clusters are grouped into four main geographical zones: north, south, east, and west zones.

Between 2000 and 2010, the proportion of the resident population who speak English predominantly at home increased from 23 to 32 percent.[7]

A cornerstone of Singapore's education is its bilingual policy. Students are encouraged to be proficient in both English, the lingua franca of the Internet, of science and technology, and of world trade, and their own mother tongue language, which could be Malay, Chinese, or Tamil, to as high a level as they are able. As a result of the bilingual education policy, among the literate resident population, the proportion of residents who are literate in two or more languages increased from 56 percent in 2000 to 71 percent in 2010.[8] English is the language of instruction for mathematics and science in all primary and secondary schools.

The Mathematics and Science Curriculum in Primary and Secondary Schools

At the primary level, all students follow a national mathematics curriculum in Grades 1–6 (Primary 1–6) and a national science curriculum in Grades 3–6 (Primary 3–6).

The O-Level, Normal (Academic), and Normal (Technical) mathematics and science syllabuses provide students from the respective courses with the necessary mathematics and science knowledge and skills in the context of a broad education in the lower secondary years. The O-Level and Normal (Academic) mathematics and science syllabuses have an academic focus. The Normal (Technical) mathematics and science syllabuses provide a strong foundation for further technical and vocational education.

Students who are talented in mathematics and science can further develop their talents in gifted programs offered in national schools or in specialized independent schools. The National University of Singapore High School of Mathematics and Science provides a broad-based curriculum, but adds special enrichment in mathematics and science, and offers students mentoring from the university's faculty. The School of Science and Technology, which opened in 2010, provides a four-year program leading to the Singapore-Cambridge GCE O-Level examination. Applied learning is pervasive in the school's curriculum. In addition to the regular subjects in the O-Level curriculum, the school offers a wider range of O-Level subjects and enrichment programs in areas related to technology, media, and design.

Mathematics Curriculum in Primary and Lower Secondary Grades

A single curriculum framework is used throughout the grade levels, differing only in the details at each level and sharing common emphases. The Singapore mathematics curriculum is characterized by the Mathematics Curriculum Framework (see Exhibit 2), which aims to develop students' mathematical abilities, with a focus on problem-solving ability.[9] Five interrelated components support the development of problem-solving abilities: concepts, skills, processes, metacognition, and attitudes. The framework provides directions for the teaching, learning, and assessment of mathematics. Exhibit 3 presents a summary of the concepts and skills to be covered by the end of Grade 8 (Secondary 2).

Exhibit 2: Singapore Mathematics Curriculum Framework[10]

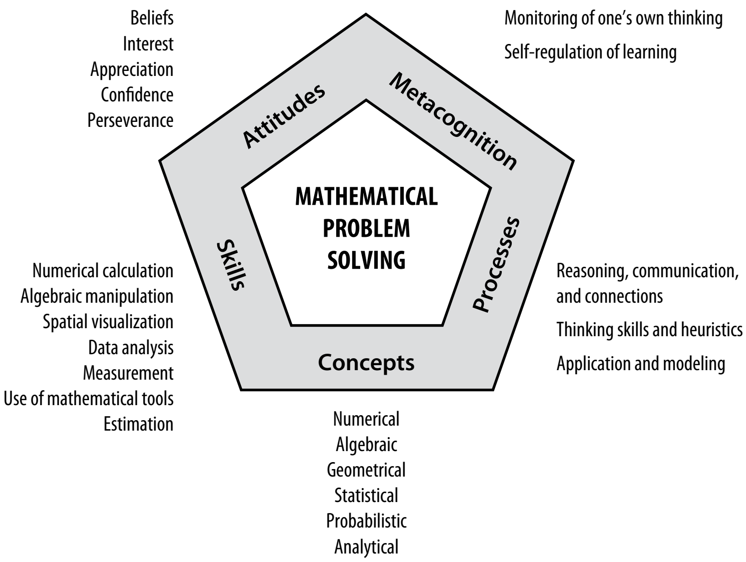


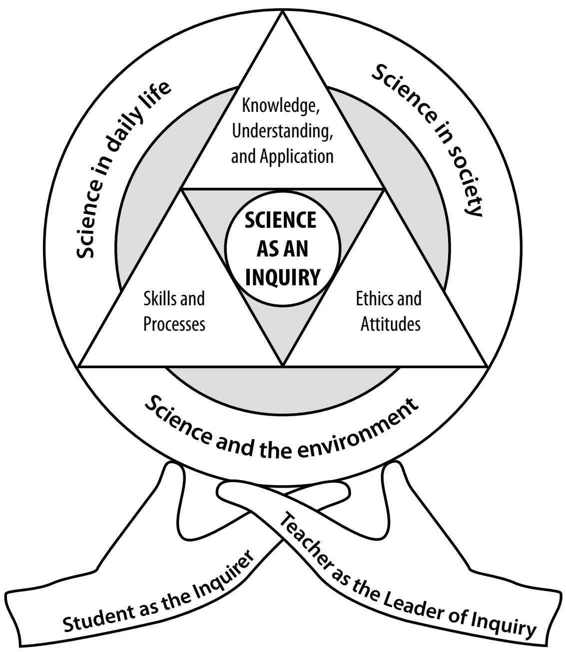
Exhibit 3: Mathematics Concepts and Skills

Primary Mathematics Grades 1–6	Lower Secondary Mathematics Grades 7–8
Numbers and Algebra	
Whole numbers, fractions, and decimals and the four arithmetic operations (addition, subtraction, multiplication, and division); Calculation with calculators; Factors and multiples; Ordering of numbers; Approximation and estimation; Percentage; Ratio; Speed; and Algebraic expressions in one variable.	Negative numbers, integers, rational numbers, and real numbers, and the four arithmetic operations addition, subtraction, multiplication, and division); Calculation with calculators; Prime numbers, highest common factor, and lowest common multiple; Ordering of numbers; Use of symbols including $<$, $>$, $\leq$, $\geq$; Approximation and estimation; Percentage; Ratio, direct and inverse proportion; Map scales; Rate and speed; Algebraic expressions and formulae; Algebraic manipulation (linear and quadratic); Functions and graphs (linear and quadratic); Linear equations with one unknown; Simultaneous linear equations with two unknowns; Quadratic equations; Linear inequalities with one unknown; and Set language and notation.
Geometry and Measurement	
Measurement of length, mass, volume, time, and angle; Area and perimeter of triangles, squares, and rectangles, area and circumference of circles, and volume of cubes and cuboids; Properties of simple geometric figures; Nets of simple solids; Line symmetry; and Ideas of tessellation.	Properties and construction of simple geometric figures; Angles associated with parallel lines; Angles of polygons; Congruence and similarity; Area of plane figures, volume and surface area of three-dimensional solids; and Pythagorean Theorem.
Statistics and Probability	
Picture graphs, bar graphs, tables, line graphs, and pie charts (including interpretation and use of information to solve problems); and Average.	Data handling (including data collection and representation); Data analysis (including interpretation and analysis of various statistical representations); and Probability.

Science Curriculum in Primary and Lower Secondary Grades

Central to the Singapore Science Curriculum Framework (see Exhibit 4) is the inculcation of the spirit and habits of scientific inquiry.[11] Inquiry is founded on three integral domains essential to the practice of science: knowledge, understanding, and application; skills and processes; and ethics and attitudes. The curriculum enables students to view the pursuit of science as meaningful and useful. Inquiry is grounded in knowledge, issues, and questions that relate to the roles played by science in daily life, society, and the environment.

Exhibit 4: Singapore Science Curriculum Framework[12]



The primary and lower secondary science syllabi are designed around themes students can relate to in their everyday experiences and on commonly observed phenomena in nature. The five themes at the primary level are: diversity, cycles, energy, interactions, and systems. The lower secondary science curriculum builds on the themes of primary science, with the addition of two themes: models and systems, and measurement. Exhibit 5 presents a summary of the topics to be covered under each theme by the end of Grade 8 (Secondary 2).

Exhibit 5: Science Concepts and Skills

Primary Science Grades 3–6	Lower Secondary Science Grades 7–8
Diversity	
Diversity of living and non-living things (general characteristics and classification); and Diversity of materials.	Classification of matter; Classification of plant and animal life; Elements, compounds, and mixtures; and Solutions and suspensions.
Cycles	
Cycles in plants and animals (life cycles and reproduction); and Cycles in matter and water.	
Energy	
Energy forms and uses (light, heat, photosynthesis); and Energy conversion.	Energy forms and conversion; Photosynthesis and respiration; Light; and Electricity.
Interactions	
Interaction of forces (magnets, frictional force, gravitational force, force in springs); and Interaction within the environment.	Concept of force and pressure; Moment of a force; Work; Effects of heat; Transmission of heat; Chemical changes; Simple concepts of populations, community, and ecosystems; Energy transfer process in ecosystems; and Nutrient cycles in ecosystems.
Systems	**Models and Systems**
Plant system (plant parts and functions, respiratory, and circulatory systems); Human system (digestive system, respiratory, and circulatory systems); Cell system; and Electrical system.	Structure, function, and organization of cells; Particulare model of matter; Simple concepts of atoms and molecules; Transport systems in living organisms; Digestion in animals; and Sexual reproduction in human beings.
	Measurement
	Use of measuring instruments; and Physical quantities and units.
	Science and Technology
	Scientific inquiry; and Science and technology in society.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Materials, Equipment, and Laboratories

Following the approval of new or revised syllabi in mathematics and science, commercial publishers are invited to develop and publish textbooks and related materials, such as activity books or workbooks for use in primary and secondary schools. These materials undergo a stringent review and authorization process by the Ministry of Education, and must meet the quality standards and requirements of the relevant syllabi before approval and placement on the approved textbook list.[13] Schools can choose the textbooks most suited to their students from this list.

Schools are provided with funds to purchase various teaching aids and manipulatives to support the teaching and learning of mathematics. These resources may be centrally stored within a school's mathematics room, which also serves as a focal point for mathematics activities and innovation, or they may be stored and made available within each classroom.

Schools also are well equipped with laboratory equipment and resources to enhance their ability to deliver the science curriculum. Primary and secondary schools are provided with science rooms and laboratories, respectively. Teachers may use these special rooms or laboratories to conduct activity-based lessons, scientific investigations, and demonstrations as well as to facilitate group work and investigative projects. Teachers also may bring science kits into the classroom to conduct demonstration lessons or engage students in hands-on learning.

Use of Technology

The Ministry of Education equips and supports schools with technology via the Masterplan for Info-comm Technology (ICT), which provides guidelines on how schools can take advantage of the possibilities offered by ICT for teaching and learning.[14]

At the primary level, Grades 1–4 (Primary 1–4) build students' foundation in basic numeracy skills, including mental computation and estimation. Starting with the 2008 Grade 5 (Primary 5) cohort, calculators are used in primary mathematics to enhance the teaching and learning process, and to allow students more time to focus on problem-solving instead of routine computations. At the secondary level, students are provided with opportunities to make effective use of a variety of mathematical tools, including calculators, graphing software, dynamic geometry software, and spreadsheets, to learn and apply mathematics. The use of calculators and other computational tools in Grade 5 and beyond does not diminish the importance of mental and manual calculations. These skills remain important; students must have good number sense and estimation skills to check the reasonableness of answers obtained using the calculators.

In science at both the primary and secondary levels, ICT supports the inquiry process and also facilitates student collaboration and self-directed learning. For example, ICT devices, such as dataloggers are used to facilitate data collection and analysis. Online collaborative tools allow students to share and discuss their ideas or findings, and also extend their learning through consultation with experts in the field. Students explore and visualize abstract concepts using animations and simulation tools to manipulate variables and deduce relationships between them.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Generally, primary-level instructors teach several subjects, such as English, mathematics, and science. A few primary schools have teachers who focus on a specific subject at the upper primary levels, although this is not common. Secondary-level teachers specialize in teaching two subjects at most. Students, therefore, have specialist teachers in mathematics and science from the lower secondary level onward.

Homework Policies

Homework is used to provide feedback on student learning, though schools and teachers decide homework policies autonomously based on student needs.

Teachers and Teacher Education

Teacher Education Specific to Mathematics and Science

The ministry recruits teachers from the top one-third of each cohort. A panel, including experienced principals, interviews and carefully selects applicants. Teachers are mainly recruited from among university graduates, as well as from the A-Level and polytechnic graduate pools. Competitive terms of employment also attract mid-career professionals from other industries who are able to inject real-world experiences into their teaching. One in eight teachers is a mid-career professional. Mathematics and science teachers in the secondary schools and in junior colleges must be university graduates in the relevant subject disciplines.

All prospective teachers are required to undergo pre-service teacher education conducted by the National Institute of Education (NIE), an institute at the Nanyang Technological University.[15] The majority of prospective teachers are university graduates in their chosen discipline. They further undergo a one-year Postgraduate Diploma in Education program at NIE to prepare them for teaching in the classroom. NIE also offers a four-year full-time program leading to a Bachelor of Arts or Science degree with a Diploma in Education. Non-degree programs include a two-year Diploma in Education offered to A-Level graduates and polytechnic diploma holders, and four-year diploma programs offered to O-Level holders (for specialized areas such as home economics, art, and music).

The teacher education program at NIE is aligned with the national curriculum and is relevant to local classroom practices. Prospective teachers in the program hone their skills in schools through teaching practica guided by experienced teachers. Beginning teachers receive structured induction and mentoring in schools, and teaching hours are reduced (by 20%) to ease them into their roles. Support for novice teachers continues after graduation.

Requirements for Ongoing Professional Development

The ministry places great emphasis on teacher development and recognition. It is committed to ensuring that teachers remain current in terms of skills and knowledge, and are well positioned for the future. All teachers are entitled to 100 hours of professional development per year. NIE works closely with the ministry to provide training courses and advanced programs, including master's and doctoral degrees. The ministry also provides specialized professional development courses to update teacher's content knowledge, and to update teachers on pedagogical innovations and new assessment modes in the teaching of mathematics and science. Since 2003, teachers also can benefit from experiential learning in research laboratories and in the business and community sectors through the Teacher Work Attachment program in addition to formal professional development courses. Through these local or overseas attachments, teachers gain new experiences that, in turn, benefit students through the fresh perspectives they bring back to their classrooms.

The ministry also encourages the growth of a teacher-led culture of professional excellence and innovation among the teaching fraternity. In 2010, the establishment of the Academy of Singapore Teachers was a significant step toward achieving this aim. This teacher-led academy fosters pedagogical leadership focused on teacher collaboration in learning communities within schools and professional networks. It aims to strengthen the culture of teaching excellence and raise the standards of practice in the classroom and across Singapore's education system.

Monitoring Student Progress in Mathematics and Science

Schools assess students both formally and informally. From Grade 3 (Primary 3), schools generally conduct at least two summative assessments each year—one at the end of each semester. For formative assessment, teachers adopt a variety of assessment methods, such as oral presentations, written tests, and portfolios. Formative assessments provide useful information for teachers to monitor student progress, identify strengths and weaknesses, and provide meaningful and immediate feedback. They also provide a more holistic approach to reporting student learning and enable teachers to modify teaching methods and materials to suit student needs and abilities.

Schools closely monitor each student's progress and work closely with parents to support student learning. Parents are advised regularly of their children's performance through progress reports, personal calls, home visits by teachers, and school-organized parent-teacher meetings.

National examinations are held in the final years of primary, secondary, and pre-university education; and they are aligned to the national curriculum. The Singapore Examinations and Assessment Board, in collaboration with the Ministry of Education, conducts these national examinations, including the PSLE, GCE N-Level, GCE O-Level, and GCE A-Level examinations.[16]

Impact and Use of TIMSS

Participating in TIMSS has provided insights into student knowledge and skills of application and reasoning in mathematics and science. TIMSS data are used to identify specific strengths and weaknesses in various domains of learning for different groups of students as well as the possible factors that contribute to variations in student performance. Information about students' common mistakes and learning difficulties is shared with teachers during meetings that the ministry holds with the heads of department for mathematics and science. Teachers work together to devise teaching and learning approaches to address their students' learning difficulties.

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The Slovak Republic

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Introduction

Overview of the Education System

Since January 2004, a new act has regulated the state administration and regional self-government of primary and secondary school education in the Slovak Republic.[1] This act decentralized the national education system ontp eight autonomous, self-governing regions (*samosprávny kraj*). At the national level, the Ministry of Education, Science, Research and Sport oversees the administration of the public school system. The ministry also is responsible for developing educational concepts and a unified educational policy, as well as for creating laws, general binding regulations, and documents related to education (such as curriculum documents). In each of the eight self-governing regions, the ministry has a school regional office (*Krajský školský úrad*) that provides professional counseling and supervision for schools and also oversees special schools and facilities. Primary schools, preschools, and school facilities are administered by an appropriate municipality, while secondary schools are administered by an appropriate self-governing region.

A principal manages each primary and secondary school. Principals are primarily responsible for curricular implementation, integration of professional and pedagogical standards into the teaching process, evaluation and ongoing education of the teaching staff, budget management and effective use of school financial resources, and the first level of state administration for individual students (e.g., admission, exclusion, delay of enrollment, permission to follow an individual study plan). The principal cooperates with a school board, which functions as a public monitor and comprises pedagogical and non-pedagogical school employees, parents, students (at secondary schools), and representatives of the municipality or self-governing region.[2]

Until 2008, primary schools based their instruction on ministry-approved study plans (*učebné plány*), syllabi (*učebné osnovy*), and content and achievement standards *(obsahový a výkonový štandard*). These curriculum documents determined the number of lessons, the content specifications for all subjects at specific grades, and the minimum level of achievement required of students.

Within the curriculum, several study plan options offered extended or additional lessons in science and mathematics, allowing schools to create differentiated classes. For example, the curriculum included several possible study plans for science in Grades 1–9 but offered alternative study plans for mathematics (allowing different numbers of classes per week) only in Grades 5–9.[3]

In 2008, the National Council of the Slovak Republic passed Act No. 245/2008 (the School Act), which addresses upbringing and education.[4] As mandated by this Act, education in schools is conducted according to the State Education Program (*Štátny Vzdelávací Program—ŠVP*) and the School Education Program (*Školský vzdelávací program—ŠkVP*). The State Education Program defines the compulsory content of education in schools, while the School Education Program is a curricular document unique to each school that describes how that particular school will attain the general achievement and content standards required by the State Educational Program. In the 2008–09 school year, this reform was introduced and applied to Grades 1, 5, and 10 (i.e., the first grades of ISCED levels 1, 2, and 3). Since then, the act has been implemented in the remaining grades. Students tested in TIMSS 2011 belong to the last fourth-grade cohort educated according to the previous policy.

There are four main levels in the education system: preprimary, primary, secondary, and higher education.

Preprimary education (ISCED level 0) is voluntary, but it is considered part of the education system and is organized according to official documents approved by the ministry. It is designed for children ages 2–6 and includes general kindergartens (*materská škola*) and special kindergartens for children with special education needs. The goal of preprimary education is to help and encourage children to interact socially with peers, develop a relationship to knowledge and learning through play, prepare for primary education, and develop their personalities. An important aspect of preprimary education is close cooperation with the child's family. In the 2009–10 school year, the gross enrollment ratio in preprimary education was 85.9 percent.[5]

Compulsory education in the Slovak Republic lasts 10 years (ages 6–16) and consists of three stages. The first two stages provide primary school (základná škola) for Grades 1–4 (equivalent to ISCED level 1) and for Grades 5–9 (equivalent to ISCED level 2). The final, tenth year of compulsory education usually coincides with finishing the first year at secondary school. Children from socially disadvantaged backgrounds who have not reached the maturity level necessary for primary school by the age of six have the option to attend an additional Grade 0. Students with special education needs can attend special primary schools.

After completing the fifth grade, students with special talents in academic subjects or art can apply for enrollment in an eight-year grammar school or the eight-year conservatory, both of which have entrance exams. In the ninth grade, students take the national examination, Testing 9, in both mathematics and their language of instruction (in addition to Slovak, if the student has studied in a minority language). Students may then apply to a secondary school, which may require them to pass an additional entrance examination.

There are three types of secondary schools: grammar schools (*gymnázium*), secondary specialized schools (*stredná odborná škola*), and conservatories (*konzervatórium*). Grammar schools offer academic courses in a variety of subjects and prepare students primarily to study at higher education institutions. Secondary specialized schools prepare students for a range of professions, from manual vocations to professional careers in such areas as business and technical fields. Conservatories prepare students for careers in the arts or for higher education study.[6, 7]

Exhibit 1 presents the duration of study, acquired level of education, corresponding ISCED level, and type of final exam required for successful completion of each type of secondary education school.

Exhibit 1: School Types in the Slovak Republic, Preprimary Through Secondary Education

School Type	Duration of Study	Acquired Level of Education	ISCED Level	Type of Graduation
Preprimary Education				
Kindergarten	Up to 4 years	Preprimary education	0	None
Grade 0	1 year	Preprimary education (optional extension)	0	None
Primary Education				
Primary—First Stage	4 years	Primary education	1	None
Primary—Second Stage	5 years	Lower secondary education	2	National examination
Secondary Education				
Grammar school	4 or 8 years	Upper secondary general education	3A	School-leaving examination certificate
Secondary specialized school	4 or 5 years	Upper secondary specialized education	3A–3B	School-leaving examination certificate
	3 or 4 years	Secondary specialized education	3C	Vocational certificate
	2 or 3 years	Lower secondary specialized education	2A–3C	Final examination
Conservatory	6 years	Higher professional education	5B	Graduate diploma

On the basis of the type of secondary education completed, students may continue their studies via post-secondary education (ISCED level 4), higher professional education (ISCED level 5B), or university education (ISCED level 5A).

Only universities provide tertiary level of education in the Slovak republic.

Languages of Instruction

The official language of the Slovak Republic is Slovak, and it is the language of instruction for most students. In certain regions, instruction also is carried out in minority languages—Hungarian, Ukrainian, German, Rutheanian, and Bulgarian. Generally, instruction in a minority language is provided at separate schools, though there are schools with joint administration that have separate classes for national language of instruction and minority language of instruction.[8]

Mathematics Curriculum in Primary and Lower Secondary Grades

Exhibit 2 presents the mathematics topics and expected capabilities that were in effect in first through fourth grades for students assessed in TIMSS 2011.

Exhibit 2: Mathematics Content Areas and Capabilities, Grades 1–4[9]

Content Area	Capabilities
Arithmetic	Read and write natural numbers up to 1,000,000; know numeration within ascending powers of 10, from 1 to 10,000; compare two natural numbers and represent the comparison using symbols (>, <, =); round natural numbers; count natural numbers; multiply and divide mentally with numbers up to 100; multiply and divide by 10, 100, and 1,000; multiply by three-digit numbers in writing; divide by one-digit numbers with remainders in writing; solve simple equations and inequalities such as $x < a$, $x > b$; and solve word problems.
Geometry	Determine the position of a point on a line segment; draw lines; differentiate among geometric shapes and objects (triangles, circles, quadrilaterals, rectangles, spheres, cubes, and cylinders); measure the length of a line segment in mm, cm, and m; draw a line segment of a specified length; convert between units of length; compare the lengths of line segments and write down the result of the comparison; draw a line perpendicular to a given line; determine the sum and the difference of the lengths of line segments; scale the lengths of line segments; draw a circle with a given point and radius; draw a triangle and quadrilateral and name the vertices and sides; draw a rectangle and quadrilateral on a square grid and name the vertices and sides; and compute the perimeter of triangles, quadrilaterals, and rectangles.

Exhibit 3 presents the mathematics topics and expected capabilities that were in effect in fifth through ninth grades for students assessed in TIMSS 2011.

Exhibit 3: Mathematics Content Areas and Capabilities, Grades 5–9[10]

Content Area	Main Topics	Capabilities
Arithmetic	Natural Numbers, Whole Numbers, and Decimals	Order numbers; compare and round numbers; add, subtract, multiply, and divide (with remainders); distinguish between prime and composite numbers; factor integers; determine the least common multiple and the greatest common divisor; find additive inverses; and use absolute values.
	Fractions	Write fractions using correct mathematical notation; order fractions; mark fractions as points on a coordinate axis; compare and simplify fractions and compound fractions; express fractions as mixed numbers; understand the concept of rational number; and add, subtract, multiply, and divide fractions.
	Percentages	Determine the value represented by a percentage; calculate percentages; use percentages to construct bar graphs or pie charts; and use percentages in basic financial calculations.
	Ratio	Determine direct and inverse proportionality; and work with scales on plans and maps.
	Powers and Roots	Read, write, and compute squares, cubes, square roots, and cube roots; perform exponentiation with natural number exponents; and perform simple arithmetic operations with exponential numbers.
	Word problems	Solve word problems.
Algebra	Expressions	Write expressions in numbers and variables; perform arithmetic operations with expressions; use formulas to expand binomials and factor polynomials (e.g., $(a \pm b)^2$, $a^2 - b^2$); and determine the equality of expressions.
	Linear Equations and Inequalities	Solve linear equations and inequalities using equivalent adjustments.
Geometry	Units	Convert between units (length, area, and weight).
	Angles	Measure and draw angles; determine complements and supplements to angles; and add, subtract, multiply, and divide angles.
	Triangles	Understand internal and external angles and their characteristics; identify types and characteristics of triangles; construct triangles; find the altitude, median, centroid, perimeter, and area of a triangle; and use the Pythagorean theorem.
	Rectangles	Identify types and characteristics of rectangles; construct rectangles; find the perimeter and area of a rectangle; and use properties of rectangles to solve word problems.
	Quadrilaterals	Identify types and characteristics of quadrilaterals; construct quadrilaterals; and find the perimeter and area of a quadrilateral.
	Disks and Circles	Find the distance between a line and a circle and the distance between two circles; calculate the circumference and area of a circle; find the distance from the midpoint of an arc to the chord cutting across it; construct and measure central angles, circumference angles, and circumcircular sectors; recognize tangents and their properties; and investigate and construct Thales' circle, inscribed circles, and circumscribed circles.

Content Area	Main Topics	Capabilities
Geometry	Congruence	Investigate congruent plane shapes; and construct images using point reflection, and axis reflection.
Probability and Statistics		Compute the arithmetic mean; solve problems using combinatorics; read and construct tables, bar graphs, and pie charts; and calculate frequency, relative frequency, and estimates of probability.

Science Curriculum in Primary and Lower Secondary Grades

Students assessed in TIMSS 2011, at the first and second grades, acquired elementary knowledge of natural science in a subject called *Prvouka* (Basics of Science) according to the previous curriculum. In this subject, students were encouraged to do the following: discover the distinctive features of living and non-living things; identify patterns of change in nature, plants, and animal life; and gain an understanding of how natural changes affect human activities. During these two grades, students worked with appropriate scientific literature (e.g., children's encyclopedias).[11]

In the third and fourth grades, students studied science in a subject called *Prírodoveda* (Natural Science), and the curriculum provided students with a comprehensive picture of the subject appropriate to their age. *Prírodoveda* covers topics ranging from the students' immediate environment to basic concepts about the universe. Later, students deepened their experience-based understanding of various concepts, including time, temperature, force, mass, weight, physical units, attributes of substances, and the states of matter (and how matter changes). Students measured physical quantities and processes, and recorded values into tables and graphs. They gained first experiences with electric circuits, electrical and magnetic properties of matter, and gravitational force. Students identified body, plant, and animal structures, as well as the functions of these parts. They deepened their knowledge of basic hygiene and good nutrition and came to understand the harmful effects of smoking or other drugs. Students explored elementary ideas about the sun, the moon, planets, and stars, and the cause of day and night.[12]

At this level, students also studied national history and geography in a subject called *Vlastiveda* (Homeland). This subject focused on nature, culture, and history, as well as on ethnography, ecology, specific regions of the Slovak Republic, and observation and orientation within the country (e.g., the direction of cardinal points). Students were encouraged to protect nature and their own health.

Science subjects were developed further at the lower secondary level within the subjects of natural history (*Prírodopis*), chemistry, and physics. The subject of natural history focuses on the study of nature, with an emphasis on basic knowledge of botany, zoology, human biology, geology, ecology, and the environment of organisms. Exhibit 4 presents the natural history topics that were in effect for eighth grade students assessed in TIMSS 2011.

Exhibit 4: Natural History Content Areas and Topics, Grades 5–9[13]

Main Topics	Sub-topics
Botany and Zoology	Internal and external structures of organisms, their characteristics, distributions, habits, and defense mechanisms.
Human Biology	Human development, populations, the structure and function of the human organism as a whole, the importance and functions of human organ systems and their functional relationships, human health and protection, and a healthy lifestyle (including sex education and an introduction to parenting skills).
Geology, Ecology, and the Environment of Organisms	The structure of the Earth, geological processes, the development of the Earth's crust and organisms, and the importance of nature conservation.

In chemistry, students become familiar with the composition of particulate matter (atom, molecule, and ion), and the composition and structure of atoms. Exhibit 5 presents the chemistry topics and expected capabilities that were in effect for eighth grade students assessed in TIMSS 2011.

Exhibit 5: Chemistry Content Areas and Capabilities, Grades 5–9[14]

Capabilities
Learn to use symbols and names of elements, to characterize the periodic system, and to distinguish among types of chemical bonds;
Acquire knowledge of different types of chemical reactions and the equations representing them, as well as the basic system of terminology for inorganic substances (e.g., alkali metal, halide, oxides, metals and non-metals, acids, hydroxides, salts) and organic substances (hydrocarbons and their derivatives) and their properties and uses; and
Learn the basics of chemical computation; perform basic activities related to observation and experiments; and gain practical experiences in the verification of theoretical knowledge.

In physics, students learn to observe physical phenomena with greater sophistication, to describe and measure physical quantities and evaluate their measurements, to use established terminology and symbols, and to apply their knowledge during experimental and problem-solving tasks. Exhibit 6 presents the physics topics that were in effect for eighth grade students assessed in TIMSS 2011.

Exhibit 6: Physics Content Areas and Capabilities, Grades 6–8[15]

Main Topics	Sub-topics
Structure of Matter	Particle composition and electrical properties of solid crystalline substances, liquids, and gases, including atoms, ions, and molecules; Brownian motion; and diffusion.
Measurement of Physical Quantities	Properties and measurements of objects, including length, volume, density, time, temperature, force and their units in the SI system (including prefixes); measuring devices and methods; and data display.
Force and Motion	Force as a physical quantity; the consequences of collisions, the composition of force vectors, and pressure; inertia, friction, gravity, and Earth's gravitational field; differentiating between linear and curvilinear motion, motion in the negative direction, and comparative calm; and graphing straight-line motion and computing average speed.
Mechanical Properties of Liquids and Gases	Pressure in liquids and gases; the influence of forces on an object in a fluid; buoyancy and conditions of sinking or floating; the Earth's atmosphere, atmospheric pressure and its measurement, and the influence of forces on objects in the atmosphere; humidity and its measurement; and basic meteorology.
Work, Energy, and Heat	Terminology used to explain work, efficiency, kinetic and potential energy and its mutual transformations, heat (receiving and transmitting), and specific heat capacity; units used to measure these aspects of work, energy, and heat; and the causes and consequences of physical changes of state (melting, freezing, boiling, condensation and evaporation).
Electromagnetic Effect	Magnetic properties of substances; magnetic fields and their representations (e.g., the Earth's magnetic field); magnetic force, and the possible interactions between two bar magnets; electrical properties of substances; electric fields and forces and their effects; fundamental parts of electrical networks and power lines; symbols used on electrical schematics; the behavior of electric currents in metallic conductors, liquids, gases and semiconductors; voltage and resistance; household current; categorizing substances as conductors or insulators; magnetic properties of electric currents (e.g., the magnetic field created when current flows through a wire coil, the effect of moving a magnet in and around a wire coil, electromagnetic induction, and the creation of alternating current); and how to construct and use an electromagnet.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Prior to 2008, the specific curriculum of each ministry-approved study plan determined the number of 45-minute mathematics and science lessons per week for students in Grades 1–9. The most common study plans included five mathematics lessons per week for students in Grades 2-7 and 9, and four mathematics lessons per week for students in Grades 1 and 8. For students in Grades 1–4, study plans usually included three to four science lessons per week. Once students began to take science as separate subjects in Grades 5–9, plans usually included two lessons per week for natural history (Grade 5-9), two lessons per week for physics (Grade 6-9) and one to two lessons per week for chemistry (Grade 8-9). This was the system of instruction in effect for students tested in TIMSS 2011.

Instructional Materials, Equipment, and Laboratories

The Ministry of Education, Science, Research and Sport regulates the selection and approval process for textbooks and other print and digital instructional materials used in schools throughout the Slovak Republic. Currently, textbooks and teaching materials that the ministry has approved or recommended are listed in a national textbook registry. The government pays the costs associated with textbook publication, and approved textbooks are available free of charge to all students. Schools also have the option of using textbooks that the ministry has recommended but has not approved; but these textbooks are not free, and either students or schools must purchase them.[16]

Teachers are responsible for selecting appropriate supplementary materials, and they often use children's science encyclopedias, movies, videos, and other digital resources in the classroom. In recent years, a number of Internet portals have allowed teachers to share teacher-generated learning materials, as well as content produced by educational publishers. Teachers also supplement their classroom instruction with field trips, such as visits to museums.

Students perform laboratory experiments in physics, chemistry, and natural history. Many schools have specialized classrooms equipped with the necessary teaching aids for this purpose.

Use of Technology

In the past decade, the availability and use of technology in schools has changed extensively. In 1999, a project called Infovek was introduced with the aim of equipping all schools with computers, multimedia classrooms, and an Internet connection. An important part of the project has been to train teachers in the basics of working with information and communications technology (ICT) and its practical application in the education process. Since the initiation of Infovek, 3,288 schools have taken part in the project and have received free Internet connections, free antivirus software, and training. Participating schools also are equipped with educational and technical software, ICT textbooks, laptops, and interactive whiteboards.[17, 18]

The Infovek project has led to a number of technology initiatives. For example, the Informativeness of Education program currently aims to integrate ICT into teaching to support the creation and operation of educational software, electronic materials, and e-learning portals. In addition, the pilot program Planet of Knowledge encourages schools to use digital textbooks in core subjects.

Teachers can use ICT (e.g., desktop computers, laptops, and interactive whiteboards) for instruction in any subject, depending on school resources. Students also can work with computers within the subject of informatics (ICT), which schools have been able to include as a compulsory subject at the first and second phases of primary education since 2005.

Curriculum documents first mention calculator use only in the additional curriculum for fourth grade, but students usually do not use calculators at this level. Students use calculators in Grades 5–9 in mathematics, chemistry, and physics, especially for complicated calculations and results verification. Calculators often help students with special educational needs to improve their achievement.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Throughout the first stage of primary schools (Grades 1–4), one teacher usually teaches all subjects. During the second stage (Grades 5–9), specialist teachers teach individual subjects. Because the subject of science is divided into chemistry, physics, and natural history in the second stage, teachers with specific qualifications teach each of these subjects. Generally, teachers at the second stage of primary school specialize in two subjects.

Homework Policies

Until September 1, 2011, Wednesday afternoons (or another school day, at individual schools' discretion) had been designated for extracurricular activities and hobbies to relax students, by Ministry of Education, Science, Research and Sport decree. Students were not to receive any homework assignments for the following school day. After September 1, 2011, references to homework were omitted from the ministry decree; currently, only teachers and schools are responsible for determining when and if to assign homework, because they best know the needs of their students.

Teachers and Teacher Education

Universities offer study programs divided into three stages: the first stage usually lasts three years and results in a bachelor's degree; the second stage usually lasts two years and results in a master's degree; and the third stage lasts three to four years and results in a doctoral degree. All primary and secondary teachers are required to complete a master's degree.

Education for teachers wanting to teach the first stage of primary school (Grades 1–4) is organized within the autonomous field of preprimary and primary education and usually takes place at Faculties of Pedagogy (university departments of education). The particular subjects taught vary among academic disciplines, but students acquire the necessary competence for teaching subjects at the first stage of primary school. Second-stage (Grades 5–9) primary school teachers and secondary school teachers typically choose to specialize in a combination of two subjects, and are educated in respective university departments that have respective courses of study.

Teaching practice is a part of preparing students for the teaching profession. It provides students with the opportunity to verify acquired knowledge in practice and to acquire practical classroom skills. The system of teaching practice usually has three phases. During the bachelor's degree program, students must complete an "inspectional practice" phase (observing the learning process in an active classroom), followed by an "assistant practice" phase (beginning to teach lessons under the supervision of an experienced teacher). During the master's degree program, students complete an additional, final phase—"coherent teaching practice"—in which they become members of teaching staff for a longer period of time. In this phase, students work under the guidance of an experienced teacher, but their work is more independent than during the assistant practice phase.

Requirements for Ongoing Professional Development

A 2009 National Council act regarding pedagogical staff and professional employees establishes the rules of professional development for teachers.[19] This act divides teachers into four main categories: novice teachers, independent teachers, teachers with first authentication, and teachers with second authentication. In the course of their professional career, teachers are encouraged to proceed through these levels. There are several ways teachers can earn the credits necessary to proceed to a higher level: attending certified professional development courses; authoring approved or recommended textbooks or other study materials; or engaging in other creative activities, such as conducting research in education.

Professional development opportunities are offered to educational staff for updating subject area knowledge and developing teaching methods and skills. Teachers are expected to continue their education on an ongoing basis. Professional development is offered in the form of training in educational management, continuous education, specialized innovation study, specialized qualification study, and extended courses, and introducing new staff to classroom practices. Several institutions provide further training for teachers, including higher education institutions, educational organizations of the Ministry of Education (e.g., the National Institute for Education, the State Institute of Vocational Education, and pedagogical educational centers), and educational organizations of other ministries, which have established some schools or school facilities.

Monitoring Student Progress in Mathematics and Science

Students in the ninth grade of primary school are involved in the national examination, Testing 9, which assesses student language abilities and knowledge in literature in the language of instruction as well as mathematics.[20] Students attending schools with minority languages of instruction also are tested in Slovak literature and Slovak language. The use of other standardized tests is not compulsory for schools, but most schools use some type of commercially prepared tests.[21] The results from this assessment can be a decisive criterion of admission to secondary schools.

Teachers conduct ongoing assessments of student progress using grades (5-point marking scale), verbal assessment, and a combination of both. Verbal assessment as the sole means of assessment can be used only up to the fourth grade. Continuous assessment is conducted throughout the school year and is based on observations, student activities, oral examinations, written examinations, and other assignments (e.g., projects). Twice each school year (at the end of January and the end of June), students receive evaluation feedback based on this assessment. The final evaluation in June is presented as a report card.

Impact and Use of TIMSS

The Slovak Republic has taken part in TIMSS since its first cycle in 1995. After both the TIMSS 2003 and TIMSS 2007 assessments, a national report was released describing Slovak students' achievement compared to their international peers, as well as important findings concerning the effects of home and school environments on students' mathematics and science literacy.

These results and findings can serve as inspiration and motivation for parents, teachers, and higher authorities.

The main program objectives of the national curriculum for primary education are to develop students' key competences, including mathematical and scientific literacy. Educational training centers in the Slovak Republic have organized several workshops focusing on teachers' lifelong learning, which have included training activities for teachers' long-term professional development in mathematical and scientific literacy. The workshops have aimed to deepen and expand teacher knowledge about the subjects by selecting and creating appropriate tasks and methods for teacher use. To this end, the TIMSS national center, the National Institute for Certified Educational Measurements, published electronic versions of TIMSS 1995 and TIMSS 2003 released items. Also, the center published TIMSS 2007 released items in the Slovak and Hungarian languages along with the accompanying scoring guides. Making the texts publicly available for use by teachers or parents was an effort to enhance students' mathematics and science literacy.

Suggested Readings

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Slovenia

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Introduction

Overview of the Education System

Slovenia is a Central European country with a population of 2,050,189 (as of January, 2011), a third of which is less than 30 years old.[1] The Constitution of Slovenia guarantees free education for all students from Grades 1–13, as well as university studies up to ISCED level 5. Education is compulsory up to Grade 9 of elementary school. At the beginning of the 2010–11 school year, there were 159,508 Slovenian students ages 6–15 enrolled in 450 elementary schools, with 335 affiliates of these schools providing instruction for Grades 1–5 only. In the same year, 1,538 students were enrolled in schools for children with special needs.[2] With the exception of three private schools, all Slovenian elementary schools are public.[3]

In Slovenia, administrative responsibilities for education are distributed among national authorities, local authorities, and schools. At the national level, the Ministry of Education and Sport is responsible for developing and implementing educational policies for all pre-tertiary education, including music, adult studies, and special-needs education.[4] The Elementary School Act describes the basic principles of compulsory schooling up to Grade 9 and determines the following: the requisite number of school days and holidays; school entry, grading, and remedial policies; and education policies for children with special needs.[5] Every year, ministry decrees provide updated lists of approved textbooks, the school calendar, financial policies for schools, and policies and amounts of governmental financial support.[6] The Ministry of Education, Science, Culture and Sport also supervises the management of schools: setting requirements concerning employment of teachers, staff, and educational facilities; specifying standards and criteria for teaching and funding; determining enrollment procedures and the rights and duties of students, teachers, and other employees; and defining the official academic calendar.[7] Lastly, the ministry specifies knowledge assessments and oversees the National Examination Center, which prepares and conducts external national examinations in Grades 6 and 9 for mathematics, Slovene, foreign languages and, in Grade 9, one additional subject determined by the ministry. This center also prepares the final examination (*Matura*) for the end of general academic secondary school (Grade 13).[8]

At the regional level, the National Education Institute provides a link between the Ministry of Education, Science, Culture and Sport and local schools, with each school assigned to one of the institute's regional offices.[9] Subject matter specialists from the institute offer schools professional counseling and help implement curricular changes and new teaching methods and technologies (e.g., ICT). The institute also prepares and implements regular teacher professional development at the regional level and develops new teaching strategies through collaboration with teachers.

Local authorities (communities) are responsible for maintaining school buildings and facilities. The ministry selects elementary and secondary school principals according to recommendations from local authorities, schools, and school boards. Each school's principal and board are responsible for hiring teachers and making decisions about the school's day-to-day work.[10]

The Council of Experts for General Education, the consultative body of the government, and the Ministry of Education, Science, Culture and Sport make decisions regarding education from kindergarten to the end of general academic pre-university programs. The Council of Experts adopts national curricula, standards of knowledge, and external examination content. It also approves textbooks, which are reviewed by the National Education Institute and its Curricular Councils, National Examination Center. The National Research Institute likewise is responsible for providing the ministry with research findings, proposals for educational changes, and data from national and international research studies as well as from national evaluations of implemented educational system reforms.[11]

The Slovenian education system consists of preschool education, compulsory elementary education (Grades 1–9), secondary education (Grades 10–13), and higher tertiary education. Preschool education is provided in kindergartens and includes daycare, meals, and education emphasizing the individuality of each child.[12] More than three-quarters of all children enroll in kindergarten, and the government encourages enrollment in kindergartens with financial support for parents.[13]

Elementary education lasts nine years and is divided into 3 three-year cycles. The compulsory portion of elementary education comprises regular morning lessons and "activity days"—individual days reserved for subject-focused activities. In the afternoon, schools offer optional activities such as art, music, sports, and foreign languages. Schools also provide educational assistance for children with special needs, additional remedial and advanced classes for main school subjects, and after-school care in Grades 1–6.

Secondary education is offered at two- to four-year vocational and technical secondary schools and at four-year general secondary schools, called *gymnasia*. In *gymnasium*, subjects are taught at the most advanced level and there is no tracking or streaming. The majority of students (40% of each age cohort) choose *gymnasia*, finish the program, and pass the *Matura*, all of which is required for university study.

Exhibit 1 presents an overview of the education levels and the mathematics and science subjects taught at each level.

Exhibit 1: Levels of Education in Slovenia

Level	Ages	General Description	Mathematics and Science Subjects Offered
Kindergarten			
Younger group Older group	1–3 3–6	Not compulsory; provides 4–9 hours of daycare and learning activities, based on national curriculum for kindergarten.	Mathematics, science, language, society, art, and sports are separate areas of the curriculum, with specific and defined learning goals and proposed activities for each age group.
Elementary Education			
Grades 1–3	6–9	Compulsory; all subjects are taught by a general classroom teacher.	Mathematics and environmental education.
Grades 4–6	9–12	Compulsory; general classroom teacher in Grades 4 and 5 for all but up to two specific subjects (e.g., music, English, sports) taught by specialists; specialist teachers for all subjects in Grade 6.	Mathematics and science and techniques in Grades 4 and 5; natural science in Grade 6.
Grades 7–9	12–15	Compulsory; specialist teachers for all subjects; students choose additional subject(s) for 3 hours per week, from science or an area of social science (e.g., experiments in chemistry, astronomy, sports, computer science, languages).	Mathematics; natural science and geography are compulsory in Grade 7; and physics, chemistry, biology, and geography are compulsory in Grades 8 and 9.

Secondary Education			
Gymnasium (Grades 10–13)	15–19	Not compulsory; offers the most advanced programs in all subjects; completing *gymnasium* and passing the *Matura* (final examination) with three compulsory and two optional subjects is required for university study.	Mathematics; physics, chemistry, biology, and geography are compulsory subjects; mathematics is taught in all four grades and science subjects in at least three grades; mathematics is a compulsory subject on the *Matura*, while science subjects are only required for some fields of study (e.g., science, medicine).
Other secondary schools (Grades 10–12 or 10–13)	15–18 or 19	Not compulsory; technical and other specific secondary schools or vocational schools; allows students to enter non-academic post-secondary programs.	Mathematics and science subjects taught in most grades, but difficulty level is lower than in *gymnasia*.
Tertiary Education			
Academic university study	19 and older	Not compulsory; most studies in the form of one- and two-year master's degrees and three-year doctoral degrees (first, second, and third levels of study according to the Bologna reform).[14]	
Non-academic post-secondary	19 and older	Not compulsory; two- to three-year programs to attain specific knowledge or vocational skills.	

Elementary and secondary schools support the well being of each child. Students from economically disadvantaged families receive additional support for school meals and transportation to schools. The Ministry of Education, Science, Culture and Sport and the Ministry for Health together provide all students with general and dental health prevention programs during school hours.

Mathematics and science subjects are an important part of elementary and secondary education. Assessment in mathematics is compulsory in all national examinations (Grades 6, 9, and 13). The grades on the mathematics and Slovene sections of the national examination in Grade 9 are used as selection criteria for entering secondary school. Because all future university students have to finish *gymnasia* with *Matura*, almost half of the age cohort receives pre-university science and mathematics education at the most advanced level and passes the final mathematics examination at the end of pre-university education.[15]

Optional lessons in advanced mathematics for interested students are offered in most elementary schools. All students may compete in national competitions in mathematics, chemistry, biology, and physics at the school level, and top achievers continue on to regional and national level competitions. The most successful students are awarded a small financial grant for gifted students ("Zois's stipend") during their secondary schooling.

The ministry also financially supports elementary students' informal learning of mathematics and science. Through the Program for Young Researchers, students can work on a one-year research project in mathematics, science, computer science, economics, or another academic area of interest under the supervision of their specialist subject teacher and compete for awards given by the Organization for Technical Culture of Slovenia.[16] Other institutions or organizations, such as the House of Experiments, the Technical Museum of Slovenia, the Festival of Science, and nature camps provide mathematics and science learning activities during regular school days or special activity weeks.[17, 18]

Languages of Instruction

The official language is Slovene (also referred to as Slovenian). According to the 2002 census, approximately 0.1 percent of the population living in Slovenia comprised members of the Italian minority and 0.3 percent of the Hungarian minority.[19] In the northeastern part of Slovenia (*Prekmurje*), all schools are bilingual (Slovene and Hungarian), while in the southwestern part of Slovenia (*Slovenian Istra*), the language of instruction is Slovene or Italian. In TIMSS, Slovenia tested students in Slovene only. Italian minority schools were not included in the TIMSS sample, while students from bilingual Hungarian minority schools were given TIMSS instruments in Slovene.

Mathematics Curriculum in Primary and Lower Secondary Grades

Mathematics topics are taught in one mathematics subject covering numbers, geometry, algebra, calculus, and statistics in all grades from 1–13. The mathematics curriculum for Grades 1–9 contains teaching goals, a list of topics to be taught, pedagogical advice, requirements for grading students, homework policies, and policies for using laboratories, ICT, and other required resources for students in early grades. The curriculum determines minimal, basic, and advanced standards of knowledge, which students should have acquired after each year of schooling, as well as a catalogue of required content and knowledge for the national examinations.[20]

In elementary school, mathematics is taught as a tool for communication, as a tool in everyday life, and as a link between a child's world and mathematical structures. Instruction also aims to deepen mathematical knowledge, build confidence in mathematics, learn about technology, and recognize mathematics as a universal interpretation of the world. The mathematics topic areas covered for Grades 1 through 8 are as follows:

- Grades 1 through 3—Mathematics instruction covers the following: geometry and measurement (orientation in space, geometrical shapes, symmetry, and basic measurement units of length, mass, volume, money and time); and arithmetic (natural numbers up to 1,000 including 0, arithmetic operations and their characteristics using natural numbers up to 1,000, and multiplication up to 10×10), parts of a whole, and data presentations (histograms and tables).
- Grade 4—In geometry and measurement, students learn to do the following: draw and recognize line segments, lines, and rays; draw rectangles, squares, disks, and circles with the help of templates; and perform operations with units of length, mass, and time. The topic area arithmetic and algebra includes adding and subtracting numbers up to 10,000, multiplying and dividing by two digit numbers, using appropriate operations to solve problems, solving expressions with brackets, and understanding the meaning of x in equations such as $a + x = b$, or $x \div a = c$. The topic area rational numbers includes learning how to divide a whole into equal parts and how to write down very simple fractions such as one-half, one-third, and three-quarters.
- Grade 5—In geometry, students learn to construct parallel and perpendicular lines, draw shapes, calculate areas and perimeters of squares and rectangles, describe cubes and cuboids, and draw nets. In arithmetic and algebra, students learn to do the following: calculate with numbers up to 1,000,000; round numbers to tens, hundreds, and thousands places; solve equations and problems; solve numerical expressions; and calculate parts of a whole.
- Grade 6—In geometry, they learn to calculate volumes and surface areas of cubes and cuboids. They encounter angles, calculate with them, and compare their sizes. In algebra, they learn to solve equations and inequalities using tables and diagrams. Students encounter decimal numbers for the first time and use them to perform comparisons and calculations. They also learn about and use fractions.
- Grade 7—In geometry, the main focus is on geometrical construction of triangles and calculations of angles and sides, as well as constructing shapes, angles, lines, and circles. Formulas are introduced for calculating the area and perimeter of triangles and squares. Geometric transformations are taught and students learn to draw reflections.

The focus in arithmetic and algebra is on operations with fractions and percentages. Unknowns and variables are introduced in number expressions.

- Grade 8—In geometry, students learn how to use the Pythagorean theorem to calculate side lengths on triangles, trapezoids, rhombi, circles, cubes, and cuboids. They calculate areas and perimeters of circles, lengths of arcs, and areas of sectors. In arithmetic and algebra, students learn about negative numbers, absolute values of numbers, continuing sequences, and using exponents and roots. The concept of function is introduced at this level. Students learn to identify the dependence between two quantities. They are taught to represent functional relations with tables of variable values and simple graphs. In Grade 8, equations still are solved informally, with formal solution methods presented in Grade 9.

In Grades 4 and 8, students do not have the opportunity to learn some of the topics appearing in the TIMSS 2011 mathematics assessment framework. Students in Grade 4 do not have the opportunity to learn decimal numbers and fractions, and Grade 8 students do not learn proportional problems, similar triangles, statistical analysis (mean, median, range, mode) and generalization of algebraic expressions (general term or variables such as x).[21] However, curriculum changes approved in 2011 propose covering these topics at earlier grades; consequently, they will be taught by Grade 4 or Grade 8, accordingly.[22]

Science Curriculum in Primary and Lower Secondary Grades

The national science curriculum consists of separate curricular documents for each science subject: environmental science, natural science, science and techniques, biology, chemistry, physics, and geography. These documents contain general goals, pedagogical techniques, explanations of methods for teaching and evaluating students' knowledge of each subject, as well as requirements for teaching specific science subjects (e.g., laboratory exercises). The documents also prescribe the minimum, basic, and advanced standards of knowledge for each grade and for the national examinations, as well as policies for using ICT and grading students.

In Slovenia, geography is not regarded as a pure science subject and in higher grades content is taught in the form of political geography of Europe and Asia (Grade 7), the world (Grade 8) and Slovenia (Grade 9). In Grade 6, both the geography and natural science subjects comprise the general geography content. In Grade 9, the Earth, the solar system, and the universe are taught in physics.

The science topics taught to Slovene students in Grades 1–9 are summarized below:

- Grades 1 through 3—Natural sciences are taught within the subject of environmental education, designed to show the great complexity, diversity, and interconnectedness of factors active in humans' natural and social environments.[23] Learning about the environment combines processes, procedures, and topics used by students to learn about the world they live in. The subject comprises natural and technical topics (chemistry, physics, biology, informatics, technical science, and technology), as well as social sciences (history, geography, communication science, sociology, economy, and political sciences). According to the curriculum's standards of knowledge, upon completion of the third grade, students should have learned about the following: themselves and the environment in which they live; their own social history; their connection to nature; the importance of health; how to define the features of materials and objects; and the physical principles of movement and force, the Earth and the universe, space and time, weather, and sound.

- Grades 4 and 5—Natural science is taught within the subject of natural sciences and techniques.[24] Students learn to describe, explain, predict, and understand the impact of natural phenomena, as well as technical and technological procedures of investigation. The main topics of this subject in Grade 4 are nutrient storage and transport, general human body functioning, diversity in nature, and the movement of planet Earth (e.g., day and night, and the appearance of shadows). The main topics in Grade 5 are nutrient storage and transport, substances in nature, living creatures interacting with their environments, food chains and networks, the impact of the sun on weather, and data display.

- Grades 6 and 7—The subject of natural science merges biology, chemistry, and physics.[25, 26] Lessons combine theory with methods of direct observation, as well as laboratory, experimental, and fieldwork. Students use information from various sources to discover the core meaning of topics. They compare, accept, and critically consider data and information and they learn how to analyze, connect, and generalize their findings. According to the standards of knowledge, students having completed Grade 7 should know about the following: the interdependence of biotic and abiotic environments; properties of forests, water as a compound, and properties of aquatic ecosystems in specific living environments; properties of the sea; physical and chemical properties of substances, and the differences between pure substances and mixtures; air properties and pollution; currents and energy; colors, the connection between light and substance, radiation, reflection, transmission, and absorption; the origin of light, refraction, reflection, and the speed of light; performance of mirrors and lenses, the formation of images in the human eye, and the function of glasses; sound as waves, the origin of sound, and terms related to sound; the occurrence of waves on the surface of water; and mechanical waves in strings and springs.

In Grade 8, natural sciences are taught as separate subjects: biology, chemistry, and physics. Lessons in all subjects include observation and experimentation, partially conducted in school laboratories. The main topics in each subject are as follows:

- Biology—Main topics are biology as a science about life, the basics of ecology, the diversity of life, and the processes of evolution.[27]
- Chemistry—Main topics are the structure of matter, chemical reactions, the atom and the periodic table, bonding, and the hydrocarbon family.[28] Teachers also choose from a list of optional additional topics. The curriculum's standards of knowledge for individual topics are symbols of elements, chemical formulas, notations for chemical changes, and reaction schemes.
- Physics—Main topics are an introduction to physics, forces, pressure, buoyancy, work, and energy.[29] Teachers also choose from a list of optional additional topics. The curriculum's standards of knowledge for individual topics are the following: explanations of physical laws and phenomena using appropriate quantities and formulas; the use of measuring devices in physics; the international measurement system; and reporting measurements by using diagrams, graphs, and tables.

According to the curriculum, Grade 4 students participating in TIMSS 2011 were taught the majority of biology and earth science topics that were included in the TIMSS science assessment framework. The discrepancy between the physics content included in the assessment framework and the Slovenian curriculum is somewhat larger. The distinction between heat and temperature is first introduced in Grade 5 (not Grade 4), when students begin to develop abstract thinking.[30] Grade 8 students do not learn about solutions, acids, bases, movement, electricity, magnetism, or human biology; these topics are first introduced in Grade 9. Curriculum changes approved in 2011 will move some of these topics to lower grades (e.g., human biology to Grade 8 and solutions to Grade 7).[31, 32]

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Materials, Equipment, and Laboratories

Students are required to have textbooks and workbooks for their use in every school subject. Teachers decide which textbooks and workbooks will be used in their classes from a list of approved textbooks and available workbooks. Students can choose to purchase their own textbooks or borrow them from free of charge the school library for the whole school year.

In general, schools have some classrooms equipped for science experiments, and a small number of schools also have a laboratory for such experiments. At least one computer room usually is available to students from Grade 6 onwards. Schools are responsible for purchasing materials to support mathematics and science instruction, such as manipulatives (e.g., counting material, cubes, geo-panels, and geometrical shapes), as well as materials requested by teachers, such as small equipment and materials for science experiments.

Use of Technology

Students are allowed to use calculators for mathematics from Grade 6 onwards, but only in a limited capacity.[33] Graphing calculators are not allowed. Students are expected, but not required, to use calculators for science subjects starting in Grade 6. In most classrooms in the lower grades, a computer is available for student and teacher use. Computer rooms, with many computers connected to the Internet, are used in most schools for regular computer-assisted lessons within different subjects in the higher grades. According to the mathematics curriculum, students should learn how to work with tables and data displays on computers from Grade 6 onwards. The curricular documents for mathematics and the different science subjects also recommend educational software for school use.[34]

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

In Grades 1–5, a general classroom teacher teaches all subjects, with the exception of music or sports in Grade 4 or 5. In Grade 1, an additional preschool teacher most frequently assists the general classroom teacher. In Grade 6, a school may decide whether students will be taught by a general classroom teacher or specialist teachers, but in most cases schools choose the latter. In Grades 7–9, all subjects are taught by specialist teachers. These teachers are specialized in and are certified to teach two subjects in specific combinations: mathematics and physics; mathematics and computer science; chemistry and physics; or chemistry and biology. In general, geography teachers do not have a second specialization from a science area but, rather, from a social science subject (e.g., history, languages, or social science).

Homework Policies

In Slovenia, students, schools and teachers interpret homework as a written piece of work for a specific subject. Individual learning from textbooks, reading for school, collecting information and data, or doing exercise problems to prepare for written and oral tests is not regarded as homework; this is called "learning for school." By Grade 8, learning for school requires much more time from each student than written homework. Schools have their own policies for assigning, checking, and correcting homework. In most cases, homework is assigned in each lesson and is checked during the following lesson. According to the curriculum, homework is not a component of a student's grade in the course.

Teachers and Teacher Education

Teacher Education Specific to Mathematics and Science

Teachers are required to have a university degree, pedagogical education, and certification. They obtain their education through required university study, induction, and professional development. Primary school teachers study primary education at schools of education at one of the three universities offering the program in Slovenia. Elementary school specialist teachers can acquire their degree in educational mathematics and science studies at schools of education or schools of science within universities. They may also complete a degree in mathematics, chemistry, biology, or physics with additional pedagogical coursework.

During university study, prospective teachers gain teaching experience by participating in (and teaching) actual classroom lessons. In addition, they must pass a practical examination in classroom teaching. After finishing university, prospective teachers apply for a one-school-year induction period of teaching in a school working under the supervision of mentor teachers. At the end of the induction period, prospective teachers must pass the national certification examination (covering subject teaching, policies, and laws). Once certified, they may apply for regular teaching jobs.

Requirements for Ongoing Professional Development

The Ministry of Education, Science, Culture and Sport offers or financially supports many forms of professional development programs for teachers: thematic conferences, regular teacher workshops organized by the National Education Institute, licensing courses, and subject matter training courses at universities and other educational institutions. The ministry motivates teachers to participate in life-long learning by linking teachers' salaries to a three-tiered national system of promotion—mentor, adviser, and senior specialist. A teacher may apply for promotion every four to five years on the basis of points earned through a variety of activities: participating in professional development or other educational programs, writing articles or textbooks, overseeing school projects or mentoring students in Young Researcher programs, or preparing students for competitions. Schools are required to allow every teacher to participate in professional development programs for at least 5 days per year. Teachers' participation in development programs is financed by the school or directly supported by the Ministry of Education, Science, Culture and Sport.

Monitoring Student Progress in Mathematics and Science

National examinations prepared by the National Examination Center monitor student achievement relative to the minimal standards defined by the curriculum and provide general feedback to the school system about student achievement. Test items are written by national subject committees and mostly contain open-ended questions. The results of the assessments are analyzed in the National Examination Center and presented to schools at regional conferences. The National Education Institute is then responsible for evaluating the results, proposing changes, and planning further development activities in elementary education.

Students are required to take external national examinations at the end of Grade 9 in their mother tongue, mathematics, and a third subject, which is selected by the Ministry of Education, Science, Culture and Sport for particular schools. Examination results are published on students' elementary school leaving certificates but are not intended as criteria for determining students' overall success. However, these results often serve as admission criteria for secondary schools (with students' consent). In 2011, this national examination system was reformed.

Teachers assess students' knowledge two to four times during a school year according to school policy, the curriculum for each subject, and the Elementary School Act. In Grades 1–3, student achievement is given in the form of descriptions. From Grade 4 onward, numerical grades are given on the national scale from 1 (fail or negative) to 5 (excellent). At the end of the school year, each teacher summarizes their students' grades from the subject taught, and students receive report cards containing final grades from all subjects.

In the last school reform, special attention was given to implementing fair grading procedures. The grading process was separated from teachers' evaluation of overall student knowledge and aimed to give students feedback only about their recent knowledge. Grades should reflect a student's achieved knowledge standard. Because the most frequently used classroom assessments are teacher-generated written and oral tests, teachers now are required to provide students with a list of standards required for each grade at the beginning of the school year. Teachers also are required to enable students to take an active role in planning dates for assessments and individual oral questioning for the whole year in advance.

Students who have received positive final grades (2 or higher) for most subjects at the end of the school year advance to the next grade. Students in the first two cycles (Grades 1–6) may proceed to the next grade even if they receive some negative (failing) final grades. Students in the third cycle (Grades 7–9) who receive a failing grade in one or two subjects must take a final make-up examination during the summer holidays in the relevant subjects. These students advance to the following grade if they pass examinations and successfully improve their grades before the next school year. Students who receive negative (failing) grades in three or more subjects must repeat the year. Students in Grade 9 have several opportunities to improve their negative final grades for a larger number of subjects. To avoid retention, schools offer regular remedial lessons, including mathematics and science subjects, during the school year for students who need additional instruction.

In the last few years, students with special needs have been integrated into regular classes in as many cases as possible. These students are expected to participate in all classroom activities, though in many cases they receive additional professional help during the school day. These students are assessed by their teachers and participate in national examinations, with accommodations when necessary. Accommodations may include having more time to take tests, taking a version of a test with fewer items or a larger font, or having an assistant write their answers for them.

Students who complete elementary school and receive a school leaving certificate may continue their education at any general or vocational secondary school, with no restrictions regarding school location.

Impact and Use of TIMSS

In Slovenia, TIMSS is recognized as an important source of ideas for changing and improving mathematics and science education. National results and international comparisons from TIMSS are used by policymakers at the Ministry of Education, Science, Culture and Sport and by specialists at other national institutions as a source of ideas for developing the learning process, particularly when making decisions about changes in curriculum, methods, and teaching priorities. Undesirable national findings have often been used as a basis for developing new national research projects or evaluations to find remedies at a national level. Consequently, some projects are designed specifically as national additions for the next TIMSS cycle (e.g., students' workload, the influence of socio-economic factors on achievement, grading of students, large regional differences in knowledge).

In the last ten years, almost all of the 450 schools in Slovenia have been included in the sample selected to participate in TIMSS at one time or another. During this period, schools and teachers have learned a great deal about the study and have become familiar with the different methods of reporting results. A national version of released TIMSS test items and other study results, such as nationally commented interpretations of benchmarking reports, descriptions of ideas for coding open-ended TIMSS items, and randomly selected student answers to open-ended TIMSS items, are used by subject and curricular specialists in regular teacher professional development sessions and in the education of future teachers. Teachers like to use released TIMSS items in their teaching and participate in expert groups or discussions about challenges in mathematics and science instruction as part of national research projects.[35]

TIMSS 2003 and 2007 findings were used in the evaluation of the 1998 national mathematics curriculum.[36] TIMSS results have uncovered gaps and weaknesses in the Slovene curriculum in addition to low knowledge expectations of students, as evidenced by low student achievement. In 2011, curricular specialists prepared a new, corrected, and improved version of the mathematics curriculum. Many changes were justified by TIMSS findings. For example, a large number of topics will be introduced earlier, algebra has been re-integrated into the program at an earlier grade (Grade 6), and abstract thinking has been re-emphasized.

Positive TIMSS science results for Slovene students have helped science educators continue teaching science as separate subjects from Grades 8–13. In addition, while recent discussions among science teachers indicated a desire to spend fewer hours teaching separate science subjects, TIMSS findings for Grade 8 students encouraged teachers and schools to retain separate subjects, and indicated that generally the curriculum is well organized.

The results from all international studies, including TIMSS 2007 science results in Grade 4, showed the need for improvement in students' explanatory and writing skills. The Ministry of Education, Science, Culture and Sport has supported a series of teacher professional development programs on the subject of reading literacy in all Slovene regions. These programs aim to improve reading literacy in science and mathematics subjects. The main teaching materials for these courses were released TIMSS science open-ended items with corresponding student responses.

Previously, TIMSS results have indicated unexpected significant differences in student achievement across the twelve geographical regions of Slovenia, despite having a highly centralized educational system. In cooperation with the Ministry of Education, Science, Culture and Sport, and with kind assistance from the International Sampling Unit for TIMSS 2011, the sample plan for Slovene schools was redesigned and extended in order to allow regional analyses of student achievement in mathematics, science, and reading (PIRLS). The results of this study are expected to receive much attention from policymakers and educators.

Similarly, it is expected that the impact of TIMSS as a necessary international comparison of achievement and as a potential link between international measurements and national findings will remain significant over the coming years. The new *White Book of Education* presents new national goals for education, and among them is Slovenia's placement within the first third of participating countries on the international TIMSS scale.[37]

Suggested Readings

Curricular documents and policies issued by the Ministry of Education, Science, Culture and Sport are published in Slovene and are available in printed or digital form. The following documents also are available in English:

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South Africa

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Introduction

Overview of the Education System

The National Department of Basic Education of South Africa is responsible for designing education policies that guide schooling practices in all nine provinces of the country. According to the National Education Policy Act, 1996 (South African Schools Act 27, 1996), the Minister of Education is responsible for defining national standards and norms for education planning, provision, governance, monitoring, and evaluation.[1] Provincial governments are responsible for implementing education policies and monitoring and evaluating progress in each of the country's nine provinces.

The South African education system is categorized into three hierarchical levels: the General Education and Training Phase, comprising reception year to ninth grade (Grades R–9); the Further Education and Training Phase, comprising Grades 10–12, including technical colleges, community youth colleges, and other non-formal post-general education; and the Higher Education Phase, comprising degree, diploma, and certificate programs up to the doctoral level.[2] The curriculum divides the General Education and Training Phase into three sub-phases: Foundation Phase (Reception year to Grade 3), Intermediate Phase (Grades 4–6), and Senior Phase (Grades 7–9).

The General and Further Education and Training Phase is compulsory and is conducted by two types of schools: public schools and independent schools (private schools). Independent schools must be registered by a head of school and must maintain standards comparable to public schools. South Africa has two types of public schools, which continue to be affected by socio-economic factors inherited from the Apartheid period: African schools, located in areas with the lowest economic status where the majority of Africans live; and multi-racial schools, comprising former white schools, Indian schools, and "Colored" schools.[a] The historical impact of these separate schools is significant, and it is very rare for other racial groups to attend African schools. In 2011, there were a total of 25,851 schools (of both types) in South Africa: 94.3 percent public, and 5.8 percent independent. The population in these schools consisted of 12,283,875 students, with 96.1 percent enrolled in public schools and 3.9 percent in independent schools. The same year, these schools collectively employed 420,608 teachers and principals, with 92.7 percent in public schools and 7.5 percent in independent schools.[3]

Languages of Instruction

South Africa recognizes eleven official spoken languages, in addition to sign language. The minister of education determines the standards of language policy, and parents have the right to choose the language of instruction for their children. In public schools, the school governing bodies decide on the school language policy and promotion of multilingualism, and the provincial education department must make provision for instruction in the chosen language.[4] According to a 2007–08 education survey, African and Indian schools prefer English as a medium of instruction, a trend in many African countries.[5] However, there is a demand for mother tongue instruction in the first three years of formal schooling. Schools with higher grades have chosen either English or Afrikaans as the language of instruction.[6, 7]

Mathematics Curriculum in Primary and Lower Secondary Grades

In 2000, the National Education Department released the *Revised National Curriculum Statement Grades R–9*, a reflection of the proposed Curriculum 2005, and the curriculum was implemented during the 2000–01 school year. Students in Grade 9 during the 2011–12 school year were taught according to this curriculum. (In 2011, this curriculum was revised as the *Curriculum and Assessment Policy Statement*, which will be implemented beginning in 2012.)

The mathematics curriculum for the General Education and Training Phase (Grades R-9) consists of five sets of learning outcomes: Numbers, Operations, and Relationships; Patterns, Functions, and Algebra; Space and Shape (Geometry); Measurement; and Data Handling.[8] Grade levels determine the focus of each learning outcome. Exhibit 1 presents a summary of the

a The term Colored refers to an ethnic group of people who possess sub-Saharan (negroid) ancestry, but not enough to be considered Black under the law of South Africa. Colored people were technically mixed race, often possessing substantial ancestry from Europe, Indonesia, India, Madagascar, Malaya, Mozambique, Mauritius, St. Helena, and Southern Africa. Indian South Africans are people of Indian descent living in South Africa.

learning outcomes and assessment standards that students are expected to have attained in mathematics in Grades R–9.

Exhibit 1: Mathematics Learning Outcomes and Assessment Standards, Grades R–9

Numbers, Operations, and Relationships	
Students should be able to "recognize, describe, and represent numbers and their relationships, and to count, estimate, calculate, and check with competence and confidence in solving problems."	
Foundation Phase (Grades R–3)	Understand that there are different kinds of numbers, their relationships with one another, the relative sizes of numbers, multiple representations of numbers and meanings, and the effects of performing arithmetic operations on numbers; count reliably (both forwards and backwards) in 1s, 2s, 5s, 10s, 20s, 25s, 50s, and 100s; know number names and symbols to 100, order and compare numbers using words "more, less, and equal," solve addition and subtraction problems with single-digit numbers orally, solve problems in groups, and explain solutions; represent even and odd numbers between 0 and 10, recognize two-digit numbers and place values, do repeated addition with whole numbers, do mental calculations with numbers up to 20, and solve problems with numbers; compose, decompose, halve, and double numbers using concrete objects and number lines; recognize South African currency and solve currency problems; multiply two-digit numbers by single-digit numbers; and divide single-digit numbers by single-digit numbers.
Intermediate Phase (Grades 4–6)	Represent numbers in multiple ways, including representations from different cultures (local and foreign) throughout history, in addition to all foundation phase concepts; recognize, represent, and know place value and compare whole numbers with at least nine digits (Grade 6); work with common fractions, equivalent fractions, and decimal fractions extending to two decimal places (Grade 6) and including measurements; demonstrate a sense of 0, additive inverse, and multiplicative inverse; know multiples of single-digit numbers to at least 100, including factors of three-digit numbers (Grade 6); recognize and use equivalent fractions, including common fractions with single-digit or two-digit denominators, decimal fractions to at least two decimal places, and percentages (Grade 6); perform mental calculations involving addition, subtraction, and multiplication (to 12 × 12). Compose and decompose numbers, mentally and round, double, and halve numbers; use calculators; recognize the reciprocal relationship between multiplication and division, and divisibility rules for 2, 5, 10, 100, and 1000 (Grade 6).
Senior Phase (Grades 7–9)	Count forwards and backwards in decimal intervals and in integers for any interval; describe and illustrate the historical and cultural development of numbers; recognize, classify, and represent integers, decimals, fractions, percentages, factors, prime factors, and numbers in exponential form in order to describe and compare them; recognize and use equivalent forms of rational numbers; solve problems in context including contexts that span areas of human rights, social, economic, and environmental issues, such as finances and measurement and technology; solve problems that include ratios and rates; estimate and calculate using appropriate operations; and perform mental calculations involving squares of natural numbers and exponents. (The above assessment standards are for both seventh and eighth grade.)
Patterns, Functions, and Algebra	
Students are expected to "recognize, describe and represent patterns and relationships, as well as to solve problems using algebraic language and skills."	
Foundation Phase (Grades R–3)	Use physical objects and drawings to copy, extend, create, and describe geometric and numeric patterns; describe, identify, and copy observed patterns, including those from geometry, nature, and cultural artifacts; and use drawings to copy patterns (Grade 2) and extend number patterns from 100 to 200 (Grade 1) and to 1,000 (by Grade 3). (The expectations for the Foundation Phase (Grades R–3) are based on laying a foundation for developing algebra skills.)

Patterns, Functions, and Algebra	
Intermediate Phase (Grades 4–6)	Study numeric and geometric patterns with a special focus on the relationships between terms in a sequence and between the number of the term and the term itself; investigate and extend numeric and geometric patterns represented in physical or diagram form, and not limited to sequences involving a constant difference or ratio, patterns found in natural and cultural contexts, and patterns of students' own creation represented in tables (Grade 6); describe observed relationships and rules; determine output values from function rules; use tables to represent functions and flow charts to represent algorithms (Grade 6); write number sentences to describe problem situations representing social, economic, cultural, and environmental issues; solve or complete number sentences by inspection or trial and error and check solutions by substitution; determine the equivalence of different descriptions of the same relationship or rule through verbal discussion, flow charts, number sentences, or tables (Grade 6).
Senior Phase (Grades 7–9)	Investigate and extend numeric and geometric patterns by investigating relationships, patterns, and rules represented in physical or diagrammatic form, not limited to sequences involving a constant difference or ratio, found in natural and cultural contexts or created by the students, or represented in tables or algebraically (Grade 8); describe, explain, and justify observed relationships, patterns, and rules; represent relationships between variables to determine input or output in multiple ways, including oral description, flow charts, and tables (Grade 8); use formulae and equations to represent functions; construct mathematical models to solve problems involving environmental issues, health issues, and issues in other contexts; complete number sentences using strategies such as inspection, trial and error, and substitution; use graphs to describe real-world numerical situations and interpret situations from graphs; determine, analyze, and interpret the equivalence of different descriptions of the same relationship or rule using the most useful representation for a given situation; use algebraic vocabulary in context (e.g., term, expression, coefficient, exponent, base, constant, variable, equation, formula, or rule) (Grade 8); classify terms, multiply, divide, compare, simplify, and write algebraic expressions using conventions, commutative, associative, and distributive laws (Grade 8).
Space and Shape (Geometry)	
Students should describe and represent characteristics and relationships between two-dimensional shapes and three-dimensional objects in a variety of orientations and positions.	
Foundation Phase (Grades R–3)	Recognize, identify, name, describe, sort, compare, and build three-dimensional objects in their surrounding environment; recognize symmetry, and describe one three-dimensional object with respect to another and follow directions as individuals and within a group (Reception year); identify, describe, sort, and compare two-dimensional shapes and three-dimensional objects (Grade 1); and construct and explore two- and three-dimensional shapes and objects (Grades 2–3).
Intermediate Phase (Grades 4–6)	Recognize, visualize, name, describe, sort, and compare two-dimensional shapes and three-dimensional objects in the environment, according to their geometric properties; build or construct, draw, and investigate two-dimensional shapes and three-dimensional objects using drinking straws, cut-out polygons, graph paper, nets, and pairs of compasses; recognize and describe lines of symmetry in two-dimensional shapes; perform rotations, reflections, and translations of geometric figures and solids, and describe them using geometric vocabulary and properties; tessellate shapes and three-dimensional objects to make patterns, discover lines of symmetry, recognize, and describe natural and cultural two-dimensional shapes and three-dimensional objects; locate positions on a scaled grid and on maps; and recognize column-and-row structure.
Senior Phase (Grades 7–9)	Identify similarities and differences among polyhedra and quadrilaterals; describe shapes in terms of sides, angles, and parallel and perpendicular sides; describe geometric figures in context, including faces, vertices, edges, sides, angles, and diagonals, with a focus on triangles and quadrilaterals; describe parallel lines cut by a transversal, perpendicular lines, intersecting lines, and triangles, with a focus on vertical angles and corresponding angles; use pairs of compasses, rulers, and protractors to construct geometric figures accurately and investigate their properties, and create nets to make models of geometric solids; use transformations and symmetry to investigate properties of geometric figures; and locate positions using compass directions, ordered pairs, and slopes.

Measurement	
Students should be able to use appropriate measuring units, instruments, and formulae in a variety of contexts.	
Foundation Phase (Grades R–3)	Describe the time of the day using vocabulary such as "early, late, morning, afternoon, and night," read clock time in hours and minutes; order recurring events in daily life, comparing them using longer, shorter, faster, and slower as measurement units of events, sequence events within one day and extend the sequence to today, tomorrow, and yesterday; use appropriate vocabulary to describe mass, capacity, and length of concrete objects; estimate, measure, compare, and order objects using non-standard measures; investigate distance, distance around, and area of two-dimensional shapes using strings and tiling.
Intermediate Phase (Grades 4–6)	Read, tell, and write analogue and digital 24-hour time to at least the nearest minute and second; solve time problems using time units, including time zones; use instruments to appropriate precision levels, including watches and stop-watches; illustrate and describe time in different cultures throughout history; estimate, measure, record, compare, and convert among appropriate units and order two-dimensional shapes and three-dimensional objects using S.I. units for mass, capacity, length, and temperature.
Senior Phase (Grades 7–9)	Solve problems related to time, distance, speed, length, perimeter, area, and volume; estimate and calculate to two decimal places; convert among S.I units; use appropriate formulae for perimeters and areas of polygons and volumes of cylinders and prisms; and describe relationships between perimeter and area of geometric figures.
Data Handling	
Students learn to collect, summarize, display, and critically analyze data in order to draw conclusions, and interpret and determine chance variation.	
Foundation Phase (Grades R–3)	Collect physical objects from the environment according to specified features, individually and within groups; sort and record collected objects as pictures or tallies, and respond to questions about the data (e.g., which is the least or most); construct pictographs and use stickers or stamps to represent individual elements in a collection of objects; describe collections of objects, explain the sorting scheme, and respond to questions about it; and use tables to present and interpret the lists of objects.
Intermediate Phase (Grades 4–6)	Pose simple questions about the environment, school, and family, and identify appropriate data sources in order to address the questions; collect data individuals and within a group; and organize and record data using tallies, tables, and graphs.
Senior Phase (Grades 7–9)	Extend data collection to appropriate sources, use simple questionnaires to collect data, distinguish between samples and populations, and suggest appropriate samples for investigations; perform simple experiments using random samples, and organize and record data using tallies, tables, and stem-and-leaf plots; summarize grouped and ungrouped numerical data by measuring central tendency; and determine measures of dispersion, including range and extremes.

Science Curriculum in Primary and Lower Secondary Grades

The purpose of learning natural science is to do the following: promote scientific literacy through the development and use of science inquiry skills in multiple contexts; apply scientific knowledge and understanding; and promote an appreciation of the relationships and responsibilities among science, society, and the environment. Three sets of learning outcomes have been put forward by the National Education Department to be implemented and assessed for promoting scientific literacy: Scientific Investigations; Constructing Science Knowledge; and Science, Society, and the Environment.[9] Exhibit 2 presents a summary of the learning outcomes and assessment standards that students are expected to have attained in science in Grades R–9.

Exhibit 2: Science Learning Outcomes and Assessment Standards, Grades R–9

Scientific Investigation	
Students will act on their curiosity to investigate natural phenomena with confidence, study and explore relationships, and solve problems in scientific, technological, and environmental contexts.	
Foundation Phase (Grades R–3)	Plan investigations by asking questions and responding to them using pictures, drawings, and other strategies; participate in planned investigations by following instructions; and describe and reflect on investigation activities by using diagrams, verbal descriptions, and explanations of what has been done; and explain the purpose of the investigation, the action plan, and an evaluation of the action plan by considering efficiency (Grade 3). (Note—This is the only set of expected science learning outcomes for students in Foundation Phase.)
Intermediate Phase (Grades 4–6)	Suggest ways of testing materials, bring personal experiences into their discoveries by highlighting those particular instances that relate to science and technology, and recognize other people's input; make note of changes and interesting details, and make discoveries by applying their own ideas and other strategies with perseverance and repetition; and conduct interviews to gather data (Grade 6).
Senior Phase (Grades 7–9)	Select testable questions, start questioning the fairness of questions, conduct comparison tests of two or more items, find useful data in books by using glossaries and indexes, and pilot data collection instruments like tests and interviews; modify vague questions to be explicit, and brainstorm suitable instruments for data collection; evaluate data and communicate findings by linking questions with supporting evidence, showing patterns and trends; and consider bias in information sources and make suggestions on further investigations that would support evidence.
Constructing Science Knowledge	
Students will be able to interpret, know, and apply scientific, technological, and environmental knowledge.	
Intermediate Phase (Grades 4–6)	Recall meaningful information, such as the names of animals in pictures, materials used in constructing everyday objects, and functional parts of structures; and categorize information by sorting on one variable (e.g., number of legs) and explain the grouping.
Senior Phase (Grades 7–9)	Distinguish vertebrates from invertebrates, list the planets in the solar system, tell how electric and magnetic forces behave, and explain what is meant by a variable in an investigation; categorize information by using simple classification systems (e.g., familiar plants by root type, household acids according to common properties, households bases by comparison with acids, and animal enclosures based on the animal's needs); describe symbiotic relationships among living things, list the steps used to separate alcohol and water, and make and use a model of a flower to explain how the parts enable pollination and fertilization; apply conceptual knowledge to unfamiliar situations, referring to appropriate concepts and process; and apply principles and link relevant concepts to generate solutions to somewhat unfamiliar problems.
Science, Society, and the Environment	
Students demonstrate an understanding of the interrelationships among science, technology, society, and the environment.	
Intermediate Phase (Grades 4–6)	Demonstrate understanding of science and technology in the context of society and the environment, describing historical and current cultural strategies of finding safe water, methods of sending messages over short and long distances, and stories of invention; suggest important discoveries that improve quality of life; and discuss the conservation and waste of resources.
Senior Phase (Grades 7–9)	Understand science as a human endeavor by identifying and explaining differences in two investigation reports, describe difficulties in observing phenomena, and suggest other strategies for acquiring better information; and understand sustainable use of Earth's resources by analyzing data and presenting the analysis as a report with recommendations; and build devices to aid in conservation of resources.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Materials, Equipment, and Laboratories

Previously disadvantaged schools have been provided with resources to assist teaching numeracy skills in the Foundation Phase, and each province implements numeracy strategies in both the Foundation and Intermediate Phase. The National Department of Education works with booksellers and publishers to develop textbooks for all learning areas, including mathematics and science; all provinces use the national catalogue of textbooks, and provincial departments are responsible for distributing all teaching and learning support materials.[10]

Use of Technology

The Teacher Laptop Initiative aims to train teachers to integrate information and communication technology (ICT) into their curriculum. In 2011, the initiative had funding available for 143,000 teachers, and teachers were awarded funds based on an application process. Fewer than 15 percent of schools in South Africa have access to computers for teaching and learning, and "very few can be described as being well resourced in terms of computers." [11]

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

The shortage of qualified teachers in South African schools has been influenced by the historical racial background of different kinds of education as well as teacher education institutions that had been segregated through race. As a result, African schools have faced a severe lack of qualified, specialist mathematics and science teachers. With the aim of transforming education in South Africa, from 2005 to 2007, the democratic government employed 1,432 foreign teachers, mostly from Zimbabwe, with mathematics and science qualifications. Since 2007, a Fundza Lusaka Bursary (scholarship) program has offered financial aid to prospective teachers who specialize in mathematics and science education. However, at the time of publication, these prospective teachers were still in college. Therefore, the cohort of Grade 8 learners assessed in TIMSS 2011 might have been taught by any of the following: qualified mathematics, science, and computer science teachers; unqualified teachers; or teachers with mathematics education but without formal teacher education.[12]

Homework Policies

South African schools design their own homework policies with the support of parents. There is no documented homework policy at the national, provincial, or even the school governing body level.

Teachers and Teacher Education

The 2007 South African Government Gazette No. 29832 provides guidelines for initial teacher education that contain two training options, regardless of specialization. The first option is a bachelor's degree in education consisting of 480 credits, including 120 credits for a practical component (a credit is equivalent to 10 lecture hours). The second option is a bachelor's degree in an appropriate subject followed by a one-year advanced diploma program in education, consisting of 120 credits beyond the subject degree.

Mathematics and science teachers have similar routes. The first option is a bachelor's degree in education comprising an academic component to strengthen the content knowledge of mathematics and science, and a professional component to learn how to teach mathematics and science.[13] The second option is a Bachelor of Science degree with an Advanced Diploma in Education or with the Post-graduate Certificate in Education. However, South African university programs vary considerably; some focus on content knowledge, while others focus on pedagogical knowledge. In general, however, the majority of programs do not provide skills and knowledge for practice.[14]

Requirements for Ongoing Professional Development

South Africa has a history of poor teacher education, especially for African teachers. Institutions have developed qualifications that will assist in upgrading teachers' skills and providing the necessary knowledge for teaching mathematics and science. Currently, the National Professional Diploma in Education and the Advanced Certificate in Education have been used as professional development for mathematics and science teachers who have no teaching qualifications in these two subjects. The professional diploma and advanced certificate also have been used to address the issue of under-qualified teachers in the system.[15] Currently, the Higher Education Quality Committee is conducting a quality review of the Advanced Certificate in Education, the results of which will determine the certificate's sustainability.[16] Concurrently, the new Continuing Professional Teacher Development system, overseen by the South African Council for Educators, has begun monitoring the quality of the teacher professional development and recording teachers' professional development points in order to incentivize continuing education.

Monitoring Student Progress in Mathematics and Science

South Africa has participated in a number of large-scale assessments in science and mathematics, including TIMSS 1995, 1999, 2003, and, now, TIMSS 2011. At a regional level, the country participated in the UNESCO-coordinated Monitoring Learner Achievement studies for Grade 4 students in 1999, in addition to SACMEQ in 2000 and 2007, which tested mathematics at the Grade 6 level. Nationally, there were systemic studies in 2001 and 2007 at Grade 3, and in 2004 at Grade 6.

South Africa is just beginning to implement a student tracking process. In 2011, the Annual National Assessments were introduced, and currently the national standardized testing of literacy and numeracy is conducted at Grades 3, 6, and 9. These assessments use samples to monitor student learning over time.[17] However, results of these assessments are not reported along with student background data, and information such as socio-economic background, culture, and parents' education background are not available to help make informed judgments.

Impact and Use of TIMSS

Since the dawn of the post-Apartheid period, TIMSS results have assisted South Africa in monitoring education reforms and changes in government policy.[18] For example, following the release of the TIMSS 1999 results, government spending was increased for mathematics and science education. In addition, the government implemented the Dinaledi Schools Initiative, which identified 100 of the country's best-performing secondary schools from disadvantaged communities and equipped these schools with mathematics and science materials to upgrade their mathematics and science teaching. Also in 2011, the Annual National Assessment was implemented to track numeracy and language performance from Grade 3.

The South African Department of Education and researchers of mathematics and science education depend on TIMSS results to conceptualize the standard of mathematics and science education instruction during the General Education and Training Phase (Grades R–9).[19] This extends to qualitatively examining teacher education and the availability of resources that make these two critical subjects accessible to learners. In 2007, a review of National policy used TIMSS 2003 results to measure South African students' performance against other countries of the world, including African countries.[20] As a result of these analyses, TIMSS 2007 testing was placed on hold while the Department of Education acted to provide schools with intensive support. The TIMSS 2011 results will assist in measuring the impact of these intervention programs.[21]

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Spain

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Introduction

Overview of the Education System

Spain is a country historically characterized by rich cultural and linguistic diversity. This diversity is reflected legally in the Spanish Constitution of 1978[1] and in the Statutes of Autonomy of the 17 autonomous communities and the cities of Ceuta and Melilla, across which the authority in Spain is territorially distributed.

The Spanish Constitution of 1978 also created a highly decentralized education system. The Spanish Government oversees legislation, basic structure, and cooperative initiatives with other nations, but the autonomous communities are responsible for all other aspects of education, including schools, curriculum, and financial and personnel management in their respective territories. Current educational regulations, including the Organic Law on Education,[2] guarantee the uniformity and unity of the education system, while also allowing autonomous communities to make individual decisions. This law includes a proposal for regional cooperation among the education authorities to develop projects and programs of general interest, share information, and benefit from best practices. Thus, the curriculum has a centralized common framework that is developed and implemented by the autonomous communities and schools.[3, 4]

In 2006, the Organic Law on Education legally validated the current basic structure of the Spanish education system, though this law did not modify the organization already established in 1990. The system is organized into school years (grades), cycles, and levels of education. The levels of education comprise preprimary education (ages 0–6), primary education (ages 6–12), and secondary education (ages 12–18).

The preprimary level of education is not compulsory. It is organized into two cycles—one for ages 0–3, and a second for ages 3–6—with the second cycle being free of charge.

Primary education (Grades 1–6) and compulsory secondary education (Grades 7–10) comprise Spain's basic education—ten years of schooling (generally ages 6–16) that is compulsory and free of charge.

Primary education (Grades 1–6) consists of three cycles of two academic years each. The Organic Law on Education established objectives that describe what student competencies should be developed at the primary level. The goal of the primary level is to provide all students with an education that allows them to concentrate on their personal development and their own well-being, as well as to acquire basic cultural skills related to oral expression and comprehension, reading, writing, and numeracy. Primary education also focuses on the development of social skills, work and study habits, and creative and emotional growth. The education provided in this level integrates different experiences and knowledge, and it adapts the instructional pace to individual student needs.

Secondary education is divided into two stages: compulsory secondary and post-compulsory secondary education. Compulsory secondary education comprises four years that generally correspond to students ages 12–16 (Grades 7–10). This stage of secondary education aims to provide students with the basic elements of culture (humanistic, artistic, scientific, and technological) that will make them conscientious citizens and allow them either to pursue subsequent studies or directly enter the job market.

The compulsory secondary education stage is organized with the goal of providing a common core education for all students while also paying attention to student diversity. Schools can organize the curriculum in a flexible way and adopt measures necessary to cater to the diversity of their students. In doing so, however, every school must ensure that all its students can reach the targets set for compulsory secondary education without any discrimination that might prevent them from achieving the final qualification.

The mandatory curriculum, both in primary education and compulsory secondary education, is organized into subject areas regulated by law. Each subject area contains objectives, content, assessment criteria, and a particular contribution to eight common basic competencies, recommended by the European Union. These eight basic competencies are as follows:

- Linguistic competence;
- Mathematical competence;
- Knowledge and interaction with the physical world;
- Information management and digital competence;

- Social and civic competence;
- Cultural and artistic competence;
- Learning to learn; and
- Autonomy and entrepreneurship.

Each subject area in the curriculum must contribute to students' acquisition of these basic competencies, though some competencies link specifically to certain subject areas, as in the case of "Mathematical competence" and "Knowledge and interaction with the physical world." By including these basic competencies in the curriculum, the Spanish education system aims to integrate both formal and informal learning, to enable students to apply their learning effectively in different situations and contexts, and to guide teaching practice by identifying essential content and assessment criteria while inspiring the teaching and learning processes.

Post-compulsory secondary education (Grades 11–12) includes the Baccalaureate and Vocational Education Intermediate Level.

Lastly, higher education includes university (ISCED 5A and above); and higher-level vocational education, higher level arts and design, and higher level sports education (ISCED 5B).

Languages of Instruction

The official language in Spain is Castilian Spanish, although four other official languages are used in different autonomous communities: Catalan, Galician, Valencian, and Basque. The language of instruction is Castilian except in communities with another official language, where schools use two official languages in education.

In Galicia, both Castilian and Galician are used, with the mother tongue used predominantly in preprimary and both languages used in primary and secondary education, so that students acquire a good command of the two languages. In the Valencian Community, Castilian or Valencian is used in schools, depending largely on the geographical location of the school as well as family choice. There are different models of instructional organization, but most schools offer a bilingual program. In Catalonia, Catalan is the language of instruction. In the Balearic Islands, both Catalan and Castilian can be used, but Catalan is the language of instruction in primary education. In Navarre and the Basque country, both Castilian and Basque are used, with variations based on the linguistic model chosen by the schools: language of instruction in Castilian or Basque and the other official language as a subject, or an intermediate option with different weight assigned to each language.[5, 6, 7, 8, 9, 10, 11]

As in other European countries, the number of schools in Spain that have adopted a "Content and Language Integrated Learning" (CLIL) curriculum, in which some of the curriculum subjects are taught in English, has grown considerably in the past decade. All the autonomous communities, with the help of the central authorities, are introducing CLIL programs in schools.[12]

Mathematics Curriculum in Primary and Lower Secondary Grades

Mathematics is one of the areas of knowledge that is taught in all six years of primary education (Grades 1–6) as well as all four years of compulsory secondary education (Grades 7–10). Mathematics is essential not only for the acquisition of knowledge that is useful in everyday life, but also for its role in the development of certain cognitive abilities.

At the primary level, mathematics learning must be essentially experiential; that is, instruction must contextualize the content in situations familiar to students, with a problem-solving perspective that provides practical application. Problem solving is one of the basic features of the mathematics curriculum because it contributes to the acquisition of basic skills such as reading for comprehension, reflecting, establishing a working plan and modifying it if necessary, verifying the found solution, and communicating the results.

The mathematics curriculum incorporates spiral learning. It is organized into four blocks whose topics are covered throughout Grades 1–6: Numbers and Operations; Measurement; Geometry; and Information Processing, Chance, and Probability. The following summary relates both the topics students learn in each block of primary school and the skills they are expected to have acquired and practiced in problem-solving contexts by the end of fourth grade:

- Numbers and Operations—(Topics) The decimal number system; the meaning of operations; computations using standard algorithms and mental computation procedures; and estimation and determination of the most appropriate method of calculation for each estimate. (Skills) By the end of Grade 4, students should be able to read and write whole numbers up to six figures, know how to compare and order them, and be familiar with the structure of the decimal number system. They should have mastered the standard algorithms of multiplication and division (one digit divisor) and be able to make reasonable estimates. Moreover, students should know the meaning of a fraction as part of a whole and be able to compare simple fractions.

- Measurement—(Topics) Estimation and calculation of magnitudes; familiarity with units of measurement and their equivalents; and selection of the most appropriate units and instruments to make reasonable estimates of measurements in the everyday environment. (Skills) By the end of Grade 4, students should know how to use the most common metric units of measurement of length, mass, and volume. They should be able to use the most common measurement instruments to estimate distance and measure familiar objects. In addition, students should know how to read and tell time (using both analog and digital watches or clocks) and manage the basic units of time. Finally, students should have begun to learn how to measure surface area by covering surfaces with geometric shapes (e.g., squares, rectangles) and non-standard units (e.g., tiles).
- Geometry—(Topics) Knowledge of geometric shapes and figures; and use of geometric knowledge to develop the ability to think, reason, and construct (e.g., build, draw, model). (Skills) By the end of Grade 4, students should be able to identify and describe elementary geometric representations (e.g., planes, models) and have been introduced to types of angles, perpendicular and parallel lines, circles, and polygons up to six sides. Students should have begun to identify and classify two-dimensional shapes and three-dimensional figures according to their elements (e.g., sides, faces, and vertices), as well as to recognize these shapes and figures in everyday life.
- Information Processing, Chance, and Probability—(Topics) Understanding of information provided by the media; presentation and organization of data using charts and graphs; and development of critical awareness about the use of information. (Skills) By the end of Grade 4, students should be able to collect and process basic data from everyday life, sort them into tables, display them in graphs (e.g., bar graphs, pictograms), and interpret tables and graphs relating to everyday phenomena. Students also will have been introduced to the language of chance and the random nature of some experiences.

In addition to these concepts and skills, the Grade 4 mathematics curriculum also covers attitudes such as the following: valuing a clear and orderly presentation of calculations, tables, and graphics; persevering in the search for solutions; having confidence in one's own abilities to develop mental calculation strategies and make reasonable estimates; and explaining one's problem-solving process.

In compulsory secondary education, students follow a common mathematics curriculum in Grades 7–9. However, because they have different interest levels, motivation, and learning styles, students can choose between two curriculum options in Grade 10: Mathematics A and Mathematics B. Mathematics A focuses on more basic operational and practical subject knowledge, while Mathematics B focuses on deeper mathematical knowledge and requires a greater use of abstract symbolism, rigorous reasoning, and formal representations.

The compulsory secondary education mathematics curriculum is organized into six blocks whose topics are covered throughout Grades 7–10: Common Contents, Numbers, Algebra, Geometry, Functions and Graphs, and Statistics and Probability. The following summary relates both the topics students learn in each block of compulsory secondary school and the skills they are expected to have acquired by the end of eighth grade:

- Common Contents—(Topics) Cross-curricular content in all areas, such as problem-solving strategies, and attitudes such as persevering in the search for solutions and assessing completed work; and use of technological tools (e.g., calculators and computers) to facilitate calculations, representations, and geometric properties. (Skills) By the end of Grade 8, students will have studied problem-solving strategies, and they should have become familiar with the analysis of problem statements, trial and error, splitting problems into parts, and testing obtained solutions.

- Numbers—(Topics) Numeracy concepts that began at the primary level extended to include all real numbers (e.g., integers, rational numbers, and irrational numbers) and new operations such as exponents (e.g., powers and roots) and logarithms; understanding of operations and practice using estimation skills and mental computation to control for possible errors in results; and numerical proportion. (Skills) By the end of Grade 8, students will have studied whole numbers, fractions and decimals, how to calculate percentages, increasing and decreasing powers of natural exponents and their operations, and scientific notation. Students also will have covered the use of the sexagesimal system for measuring time and angles. Their study of proportionality will have extended to inverse proportions.

- Algebra—(Topic) The use of algebraic language (e.g., polynomials and equations). (Skills) By the end of Grade 8, students will have learned about first-degree binomials and should know how to solve linear equations and use linear equations to solve problems.
- Geometry—(Topics) Calculation of surface areas and volumes; description of geometric figures; and analysis, classification, and relationships between elements of geometric figures. (Skills) By the end of Grade 8, in plane geometry students will have studied the Pythagorean theorem, similarity (e.g., similarity ratio and scales), and Thales' theorem. In solid geometry, students will have studied the basic elements: points, lines and planes, the relationships between them (e.g., incidence, parallelism, and perpendicularity between straight lines and planes), geometric figures, and the calculation of surface areas and volumes.
- Functions and Graphs—(Topics) Different types of functions (e.g., constant, linear and related, quadratic, exponential, and logarithmic) and their characteristics, with an emphasis on graphs (e.g., points of intersection with the axis, growth and decay, continuity, and symmetry). (Skills) By the end of Grade 8, students will have studied the characteristics of a function and its graph, as well as linear and inverse proportionality functions. Students also will have begun to use a graphing calculator and computer applications for drawing function graphs.
- Statistics and Probability—(Statistics topics) Basic concepts such as population, sample, discrete and continuous variable, organization of data in frequency tables and statistical graphs, and calculation of central tendency and dispersion measures to prepare students for critical analysis of statistical information. (Probability topics) Simple and compound probability, including randomized experiments, the assignment of probabilities by Laplace's law, contingency tables, and tree diagrams. In Grade 10, Mathematics B topics also include combinatorics, applications to the calculation of probability, and conditional probability. (Skills) By the end of Grade 8, students will have studied various elements of statistics: absolute, relative, and cumulative frequency tables; statistical diagrams, including pictograms, population pyramids, and climate diagrams; and calculation of the mean, median, and mode. Students also should have learned how to use spreadsheets to organize data, perform calculations, and create graphs.

Science Curriculum in Primary and Lower Secondary Grades

In primary education, instruction is structured around areas of knowledge. Most of the scientific content is included in the Knowledge of the Natural, Social, and Cultural Environment. Among other objectives, this area of knowledge is explicitly designed to provide the foundation upon which science education will be built in later stages, through topics such as valuing and appreciating the natural environment and its care, valuing hygiene and health and accepting one's body, and knowing and valuing familiar animals. However, at this educational level, the curriculum is global and integrated across subjects, so science education is enriched by contributions from other areas, and in turn will contribute to the achievement of more general educational objectives, including values, study habits, social skills, and communication skills.

The selection of content and organization of the primary education science curriculum reflects the relationship between science, life, and students' interests more than structured knowledge according to scientific logic. Science at the primary level includes the following blocks of content:

- The Environment and Conservation—Basic elements of the physical environment (i.e., universe, air, and water) and introduction to the knowledge of ecosystems;
- The Diversity of Living Things—Recognition of the existence of multiple forms of life, and their classification based on characteristics with scientific significance (e.g., types of nutrition and environmental adaptation);
- Health and Personal Development—Organ systems of the human body and healthy lifestyles;
- Matter and Energy—Mass and volume, power, energy and change, and energy sources; and
- Objects, Machines, and Technology—Materials and their uses, tools, mechanical operators, electronic devices, and information technology.

Students are evaluated in terms of skill acquisition, with particular emphasis on the significance of the knowledge acquired, which is observed through students' ability to give examples, classify, locate items in schemes, and relate causes and effects. Thus, the skills, goals, and content (and implicitly the methodologies) in the curriculum set the level of progress that is expected from students throughout their educational process.

In particular for the fourth year of primary education, the evaluation criteria are as follows:

- Recognize and explain relationships among physical world factors (e.g., soil, climate, topography, vegetation) and the ways of life and actions of people, adopting an attitude of respect for ecological balance;
- Identify and classify animals, plants and rocks, according to scientific criteria;
- Identify and explain the consequences for one's health and personal development of certain eating habits, hygiene, physical exercise, and rest;
- Identify the main human uses of natural resources, noting advantages and disadvantages, using examples taken from daily life;
- Identify sources of energy, including methods and machines to acquire energy, give examples of uses of energy, and value the responsible use of energy;
- Analyze parts of objects and machines and their functions, planning and executing the construction of an object, showing attitudes of cooperation and attention to safety; and
- Obtain information about facts or phenomena, make predictions about natural events, integrating observational data and querying basic sources, and communicate results through abstracts, images, graphics, and diagrams.

At the secondary education level, the science curriculum is organized into subjects. In Grades 7–9 (the first three years of compulsory secondary education), Natural Science is a single core subject. In Grade 10, students have the option of choosing between two science subjects: Biology-Geology and Physics-Chemistry. Throughout this stage, students systematize and formalize their knowledge of science by learning the concepts and methods of the different scientific disciplines. The science curriculum objectives focus on understanding and applying scientific concepts, methods, and procedures and acquiring scientific attitudes, values, and habits.

The compulsory secondary education science curriculum is divided into blocks for each year. One block covers cross-curricular topics across the four grades, focusing on scientific methods and procedures (e.g., formulating hypotheses, designing experiments, interpreting information sources, and using tools). The remaining four blocks are organized around key structural concepts:

Matter, Energy, Unity and Diversity, and Change and Interaction. These blocks cover conceptual and substantive topics and are distributed as follows:

- Grade 7—Earth in the universe (e.g., solar system, planets, etc.); Earth's structure (geosphere, atmosphere, hydrosphere); matter and its states; and living things and their diversity (e.g., vital functions, the cell, classification of living things, the five kingdoms of nature).
- Grade 8—Matter and energy (changes, sources, and transfers of energy); geological transformations (geological processes, rocks, origin of relief); life in action (vital functions, including nutrition, interaction, and reproduction); and the environment (ecosystems, biotic and abiotic factors, organisms, and consumers and decomposers).
- Grade 9—Physics and chemistry topics such as the unity and diversity of matter, the structure of substances, and chemical changes; and biology and geology topics such as health, the environment, and transformations due to external energy.
- Grade 10—Students can choose either of these two subjects: Physics-Chemistry and Biology-Geology.

In Grade 7 science, assessment focuses on students' ability to apply scientific knowledge to real-world situations and contexts. According to the evaluation criteria, seventh-grade students are expected to do the following:

- Interpret natural phenomena (e.g., day and night, time and seasons, eclipses, and tides) using models of the solar system and the movements of the moon, the Earth, and sun;
- Describe the observations that make it possible to understand the universe (e.g., sphericity, movements of the Earth, heliocentric and geocentric systems);
- Interpret the properties of matter (e.g., mass, volume) and the procedures used to investigate them;
- Relate the properties of materials to their common uses, differentiate between compounds and mixtures, and apply separation techniques;
- Know the properties of air and the atmosphere, recognize the impact of human activity on them, and interpret weather phenomena;
- Explain the properties of water, the water cycle, the importance of water for life, and the impact of human activity on water resources;
- Identify the most common rocks and minerals and their applications;

- Recognize the cellular constitution of living things and their vital functions; and
- Classify living things into major taxonomic groups.

In Grade 8 science, students are expected to do the following:

- Use the concept of energy to explain changes, and recognize renewable and non-renewable energy sources in addition to their advantages and disadvantages;
- Differentiate between heat and temperature and understand how they are measured, solve problems by applying concepts of thermal equilibrium, and recognize the effects of heat and movement of heat;
- Explain natural phenomena related to sound and light transmission (e.g., reflection, refraction, optical devices);
- Identify the effects of geological processes on the Earth's surface and explain the formation of igneous and metamorphic rocks;
- Recognize the risks associated with geological processes and how to avoid those risks;
- Know the vital functions of living things (autotrophic and heterotrophic nutrition, types of reproduction, and interaction); and
- Identify the biotic and abiotic components of an ecosystem, diagram trophic relationships, identify the Earth's major biomes, and recognize the importance of preserving ecosystems.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

The official national curriculum is interpreted by each autonomous community and is further developed by individual schools through their specific educational projects and Annual School Program. Schools adapt these documents to the characteristics of their own cultural and social environment by establishing their own syllabi, teaching materials, and extracurricular activities.

Teachers establish the final level of curricular specificity by planning their lessons and selecting the appropriate teaching strategies, resources, and activities. In primary school, teaching units are frequently based on students' own experiences. In science, for example, students might study the seasons of the year, food preparation, and parks and gardens. In mathematics, they might solve word problems about everyday situations and create graphs and charts on sports results, common objects, or geometric shapes. However, in secondary education, the science curriculum is progressively based on the logical structure of the disciplines and sciences (e.g., chemical reactions, geological processes, and diversity of living things). In the mathematics curriculum, concepts and activities become increasingly more abstract (e.g., introducing algebra and using mathematics language).

Instructional Materials, Equipment, and Laboratories

Textbooks are chosen by school departments (cycle-based in primary schools and subject-based in secondary schools) under the system of school autonomy described above. Individual teachers also have the option to prepare and use their own instructional materials. In either case, teaching materials must be reported on the school's official documents—the Annual School Program in particular, which includes the Cycle Teaching Programs (in primary schools) and the Subject Department Programs (in secondary schools). The Education Inspection Service monitors these documents.

Primary schools are not required to have laboratories, although there are often classrooms in which experiments can be conducted. Secondary schools are required to have at least one science laboratory for every twelve students.

Use of Technology

The Spanish education system currently is undergoing a rapid growth of new technologies. Consequently, schools are increasing the quantity and use of computing equipment and adjusting teacher education to account for these changes. Most autonomous communities are updating classrooms and libraries in all schools to provide quick access to information and communication technologies (ICT) and to ensure that students have access to digital environments. All schools have computer rooms and digital portable projectors, and some classrooms also are equipped with interactive whiteboards. In addition, schools have an ICT coordinator, and virtual classrooms, educational blogs, and platforms for online activities are quite common and continue to expand.

Official curricula in mathematics specify the use of graphing and scientific calculators, spreadsheets, and other specific mathematics software.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Specialist teachers for mathematics and science are mandatory from the first year of secondary education (Grade 7) onward.

Homework Policies

There are no mandatory homework policies specified by Spanish education legislation. Teachers plan and schedule homework according to their professional judgment and criteria, adapting it to the specific characteristics of their classes to promote student acquisition of knowledge and competencies.

Teachers and Teacher Education[a]

Teacher Education Specific to Mathematics and Science

In primary education, generalist teachers teach mathematics and science (Knowledge of the Social, Natural, and Cultural Environment) subjects. Beginning in 2010, the Primary School Teacher university degree was extended from three to four academic years, following the European process of convergence. The curriculum includes mathematics and science fundamentals and their pedagogy among the core subjects, as well as other optional courses related to these disciplines, and a compulsory practicum.

Since the 1990s, most primary school teachers have followed a generalist education program, with the exception of specialist teachers in foreign language, music, physical education, and special needs. However, some current primary school teachers followed the previous teacher education programs established in the 1970s. At that time, General Basic Education (EGB) covered Grades 1–8, and teachers chose between generalist and specialized education programs. To teach in Grades 6–8, teachers could choose to specialize in mathematics or science. Under this previous system, secondary teachers were required to have a bachelor's degree in education, or an engineering or architecture degree in conjunction with a certificate in pedagogy, which was obtained by completing a short course on teaching theory in conjunction with a brief practicum. Since 2010, this certificate has been replaced by a master's degree in Secondary School Teacher Training.

a For recent legislative changes affecting the university training of teachers of Primary and Secondary education, refer to the following: *Ley Orgánica 2/2007, de 12 de abril, por la que se modifica la Ley Orgánica 6/2001, de 21 de diciembre, de Universidades* (Organic Law 2/2007 that modifies the Organic Law 6/2001 about Universities); *Real Decreto 1393/2007, de 29 de octubre, por el que se establece la ordenación de las enseñanzas universitaria oficiales* (Royal Decree 1393/2007 that orders University studies); *Orden ECI/3857/2007, de 27 de diciembre, por la que se establecen (…) titulos universitarios oficiales (…) de Maestro en Educación Primaria* (Order ECI/3857/2007 that states the curriculum and organization of the University Grade for Primary Teacher). Retrieved from http://www.boe.es/boe/dias/2007/12/29/pdfs/A53747-53750.pdf; and *Orden ECI/3858/2007, de 27 de diciembre, por la que se establecen los requisitos para (…) títulos universitarios oficiales (…) Profesor de Educación Secundaria (…)* (Order ECI/3858/2007 that states the curriculum and organization of the University Master for Secondary Teacher). Retrieved from http://www.boe.es/boe/dias/2007/12/29/pdfs/A53751-53753.pdf

Teachers obtain a teaching position through either an open competition at public schools (both primary and secondary) or a private contract at private schools.

Requirements for Ongoing Professional Development

According to educational legislation, teachers have both a right and a duty to participate in professional development. Apart from postgraduate courses, education-training centers offer both classroom and online courses, as well as support for teacher-initiated seminars and working groups, though these options vary by autonomous community. Every six years, teachers in public education can receive financial incentives for participating in professional development activities.

Monitoring Student Progress in Mathematics and Science[13]

External large-scale evaluation studies are well established in Spain. These studies focus on key competencies and have a diagnostic purpose. There are two different levels: the General Diagnostic Evaluation is conducted at the national level and administered to a national sample of students, and the Diagnostic Evaluation is conducted by the autonomous communities and administered to a census of students. The General Diagnostic Evaluation provides important data used to evaluate the educational system and compare results among communities, while the Diagnostic Evaluation aims to evaluate individual schools and provide them with feedback. Both diagnostic evaluations on the acquisition of key competencies are carried out in Grades 4 and 8, though some autonomous communities also administer external assessments at other grades.

Primary school teachers are responsible for evaluating individual student progress. The evaluation of student achievement is ongoing and global and takes into account student progress in all areas and elements of the curriculum. Teachers use the evaluation criteria specified for a content area as the basis for determining the level(s) of competence that the student has attained. Primary schools use qualitative grades to inform students and their parents about student learning progress at the end of each term. When a student's progress is inadequate, schools must adopt remedial measures as soon as the difficulties are detected. These measures are designed to guarantee the acquisition of essential skills so that the student can progress within the education system.

Schools use assessment results to plan interventions to guarantee student achievement in key competencies during the third cycle of primary education

(Grades 5–6). These results allow schools both to evaluate instruction and teacher performance, and also (where appropriate) to analyze, evaluate, and redirect the actions they developed for the first two cycles of this level. At the end of the primary level, the school prepares a report evaluating the degree to which a student has achieved the expected learning skills, particularly those that most affect their educational progress.

Impact and Use of TIMSS

Spain participated in TIMSS 1995 but since then has not participated in TIMSS until 2011. For this reason, the impact of TIMSS will be observed after the publication of the international report.

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Sweden

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Introduction

Overview of the Education System

A fundamental principle of the Swedish education system is that all children and young persons shall have equal access to education, irrespective of gender, geographic residence, or financial circumstances.[1] Excluding preprimary education for children up to the age of six, for which parents pay a subsidized fee, all education in Sweden is free of charge and available to all.[2]

On July 1, 2011, the Swedish school system underwent a profound reform. This reform includes a new national curriculum and syllabus, a new school law, a new system for grading and national tests. As a part of the reform, teacher education also changed in several ways, such as a new requirement that teachers, including preprimary teachers, must be certified to obtain permanent employment. However, because these reforms were introduced after the TIMSS 2011 assessment, this chapter describes the conditions and contexts that were in effect under the previous curriculum and regulations.[a]

The Swedish education system is highly decentralized. The parliament and government define national goals, curriculum, and syllabus while central authorities, municipalities, and various institutions ensure that educational activities are implemented in line with the legislative framework and that these activities address the national education goals. All municipalities are required to set general objectives for their schools in a school plan based on the national Education Act, curricula, and syllabi. Adopted by the municipal council, this school plan must clearly state the measures the municipality intends to take to meet the national education goals. Every municipality is required to present an annual quality report and to evaluate and update its school plan on a regular basis. The national budget includes grants to the municipalities for their various functions in regard to education. Each municipality decides how to distribute the grants between schools. The government only have a small

a For more information about the new (2011) curriculum and regulations, please see http://www.skolverket.se/

amount of grants (about 4% of the total schools budget) that they direct to specific educational campaigns.[3]

In addition, each school is required to establish a local work plan based on the national goals and the municipal school plan. This work plan should define content that is not determined by the national steering documents, such as course content, organization, and teaching methods. The work plan should be developed by the head of each school in consultation with the teachers, other school personnel, and student and parent representatives.

The Swedish National Agency for Education (*Skolverket*) monitors, evaluates, follows up on, and supports the local development of the quality of preschools, schools, and adult education centers, while the Swedish Schools Inspectorate (*Skolinspektionen*) provides supervision. The National Agency for Higher Education (*Högskoleverket*) is responsible for monitoring, evaluating, following up on, and supervising higher education institutes. The National Agency for Special Needs Education and Schools (*Specialpedagogiska skolmyndigheten*) coordinates government support for special needs education. The Child and School Student Representative (*Barn- och elevombudet*) supervises the section of the Education Act that relates to protecting students from degrading treatment.[4]

There are only a few strictly private national schools, although there are a growing number of grant-aided independent schools at the lower- and upper-secondary level. Independent schools must be approved by the Swedish Schools Inspectorate but anyone is free to apply and the schools are allowed to make a profit. These schools receive municipal grants based on the number of enrolled students per academic year. All schools follow the same goals, but independent schools may have a distinct profile.

Preprimary education and care are provided at preschools (*förskola*), family daycare centers (*familjedaghem*), and open preschools (*öppen förskola*). The aim of preprimary education is to create favorable learning conditions that stimulate a child's physical and mental development. In Sweden, 83 percent of all children ages 1–5 attended some form of preprimary education in 2010.[5] In addition, six-year-olds may attend preschool classes (*förskoleklass*), which aim to provide a sound base for the first grade of compulsory schooling.[6] Preschool classes are usually organized within compulsory schools and are free of charge. Although attendance is voluntary, 96 percent of six-year-olds were enrolled in 2010.[7, 8] Until the age of twelve, children may also attend leisure-time centers (afterschool programs) after the regular school day at preschool or compulsory school.

Compulsory education is carried out in a nine-year comprehensive school for children ages 7–16 (Grades 1–9), though if parents prefer, children may start school at age 6. This education system comprises compulsory school (*grundskola*), Sami school (*sameskola*) for Sami-speaking children in Grades 1–6, special schools designed for children and adolescents who are deaf or hearing impaired and can not attend compulsory school (*specialskola*), and schools for children with learning disabilities (*grundsärskola*).[9] About 12 percent of students attended independent compulsory schools in 2010–11.[10]

A Compulsory School Leaving Certificate qualifies students to apply for upper secondary school, which comprises Grades 10–12. Passing grades in Swedish, English, and mathematics are required for admission to a national program, and almost all students who complete compulsory school (99% in 2010–11) continue on to upper secondary school.[11] The majority of these students attend public upper secondary schools, and about 24 percent attend independent upper secondary schools.[12] Upper secondary school is divided into 18 different three-year national programs, all of which are intended to provide a broad-based education and result in general eligibility for further studies in higher education. In addition to the national programs, there also are specially designed individual study programs. The majority of students (68% in 2006–07) complete their upper secondary education in three years.[13]

Universities and university colleges are also free of charge, and admission is either based on grades, a university admission test (*högskoleprovet*), or a combination of interviews and tests. Students also may attend post-secondary vocational schools to prepare for a specific trade or occupation.

The Swedish national government has expressed concern about Swedish education in several areas associated with mathematics, technology, and natural sciences, including the knowledge and interest of students, the competence of teachers, recruitment to higher education in science and engineering, and gender distribution in higher education.[14]

To address these concerns, the Swedish National Agency for Education supports national resource centers in mathematics, science, and technology. In addition, together with the National Center for Mathematics Education (NCM), the national agency supports municipal mathematics developers, whose task is to conduct development work and mediate new research on a local and long-term basis. About 75 percent of all municipalities have been participating actively in this project since its launching in 2006. The Technology Delegation (*Teknikdelegationen*) was introduced in 2008 by the government to promote greater interest among children and young people in mathematics, science, engineering and ICT. In addition, the MST Initiative 2009–11 (*Regeringsuppdraget att utföra utvecklingsinsatser inom matematik, NO och teknik*) was designed to improve mathematics, technology, and science teaching in compulsory school as well as increase student achievement and encourage student interest in higher education in these subjects (see the Impact and Use of TIMSS section for further information about these two initiatives).

During the past five years, a campaign by the Swedish government called "reading-writing-counting" (*läsa-skriva-räkna*) has directed all schools to increase basic skills in reading literacy and mathematics.[15] The national government has also assigned the Swedish National Agency for Education a mission to design and plan a program in pedagogical training for mathematics teachers. Training will start in 2012.

Languages of Instruction

In Sweden, the national language is Swedish. There are five official minority languages in Sweden: Sami, Finnish, Meänkieli, Romani Chib, and Yiddish. All students are entitled to learn a foreign language and their mother tongue or a minority language.

The principal language of instruction is Swedish. Students with a native language other than Swedish can take the subject Swedish as a Second Language to help them acquire a functional mastery of the Swedish language comparable to that of students who have Swedish as their native language. The subject Mother Tongue is taught to give students with a native language other than Swedish opportunities to further develop knowledge of their native language. Overall, language instruction has the important task of supporting student acquisition of knowledge in all subjects.

The Swedish Curriculum in Primary and Secondary Schools

The Swedish curriculum for compulsory school is taught nationwide. General educational goals are outlined in the curriculum and subject-specific goals in the syllabus, both of which are rather brief and concentrated documents.[16] The syllabus delineates two basic sets of objectives: goals to aim for and goals to be attained. The goals to aim for indicate the orientation of school activities, while the goals to be attained state the minimum levels to be achieved by students by the end of the fifth and ninth school years. The goals to be attained specify the lowest acceptable level of knowledge. The school and its organizer are responsible for ensuring that students are given the opportunity to attain at least this level of knowledge. Most students can and should exceed this level.

The only mention of mathematics in the national curriculum is that students should have a mastery of basic mathematical principles and be able to use these in everyday life. With regard to science, the curriculum states that a student should know and understand basic concepts and contexts within the natural sciences as well as within technical, social, and humanistic areas of knowledge.

Mathematics Curriculum in Primary and Lower Secondary Grades

Compulsory schools are tasked with developing student knowledge of mathematics needed to make well-founded decisions in everyday life and ability to interpret and use the increasing flow of information to follow and participate in decision-making processes in society. The subject mathematics should provide a sound basis for studying other subjects, for further education, and for lifelong learning. Mathematics is an important part of Swedish culture and mathematics education should give students insight into the subject's historical development and its importance and role in Swedish society. Mathematics education aims at developing student interest in mathematics as well as creating opportunities for students to communicate through mathematical language and expressions. It also should give students the opportunity to discover the aesthetic value in mathematical patterns, forms, and relationships, as well as experience satisfaction and joy from understanding and solving problems. The subject should give students the opportunity to practice and communicate mathematically in meaningful and relevant situations through actively and openly searching for understanding, new insights, and solutions to different problems.

In terms of "goals to aim for" when teaching mathematics, the syllabus states that schools should aim to ensure that students develop the following:

- Interest in mathematics, as well as confidence in their own thinking and their own ability to learn and use mathematics in different situations, appreciation for the important role mathematics plays in different cultures and activities, and familiariarity with historical contexts in which important concepts and methods in mathematics are developed and used;

- Appreciation for the value and use of mathematical forms of expression;
- Ability to understand, carry out, and use logical reasoning, draw conclusions, and generalize, and explain and provide arguments for thinking, both orally and in writing;
- Ability to formulate, represent, and solve problems with the help of mathematics, as well as interpret, compare, and evaluate solutions in relation to the original problem situation;
- Ability to use simple mathematical models, as well as critically examine the assumptions, limitations, and uses of these models; and
- Ability to use pocket calculators and computers.

In addition, students should develop their numerical and spatial understanding, as well as their ability to understand and use the following methods and concepts:

- Basic numerical concepts and calculations with real numbers, approximate values, proportionality, and percentages;
- Different methods, measuring systems, and instruments to compare, estimate, and determine the sizes of important orders of magnitude;
- Basic geometrical concepts, properties, relations, and propositions;
- Basic statistical concepts and methods for collecting and processing data as well as for describing and comparing important properties of statistical information;
- Basic algebraic concepts, expressions, formulae, equations, and inequalities;
- Properties of different functions and their corresponding graphs; and
- The concept of probability in applied contexts.

In terms of "goals to be attained," the syllabus states that students should have acquired a basic knowledge of mathematics needed to be able to do the following by the end of the third year of compulsory school:

- Interpret information of a mathematical nature relevant to specific contexts;
- Express themselves orally, in writing, and through their actions in an understandable way by means of everyday language, basic mathematical concepts and symbols, tables, and pictures; and

- Explore mathematical problems within specific contexts and try out and choose methods of solution and calculation, as well as assess the reasonableness of their solutions.

Within this framework, students should be able to perform mathematical tasks in the following areas:

- Numbers and Their Representation—Read and write numbers and also indicate the value of an integer in the range 0–1,000 by its position; compare, order, and divide integers in the range 0–1,000; divide integers into different factors, and be able to describe, compare, and show parts as simple fractions; describe patterns in simple number sequences; and handle mathematical equivalences for integers in the range 0–20.
- Calculations with Positive Integers—Explain what the different arithmetic operations represent and their relationships with each other by using concrete materials, and pictures; mentally use the four arithmetic operations where numbers and answers are integers in the range 0–20 and for simple integers in higher ranges; and add and subtract numbers using written methods of calculation in cases where numbers and answers are in the range 0–200.
- Spatial Relationships and Geometry—Describe the location of an object by using coordinates; describe, compare, and name common two- and three-dimensional geometrical shapes and objects; draw and represent simple two-dimensional figures, and also follow instructions for building simple three-dimensional objects; and continue and construct simple geometrical patterns.
- Measuring—Make simple comparisons of different lengths, areas, masses, volumes, and times; and estimate and measure lengths, masses, volumes, and time using standard units of measurement.
- Statistics—Interpret and present simple and everyday information in tables and diagrams.

By the end of the fifth year of compulsory school, the "goals to be attained" section of the syllabus states that students should have acquired the basic knowledge in mathematics needed to describe and solve theoretical problems and solve application problems in their immediate environment. Within this framework, students should be able to do the following:

- Have a basic understanding of numbers, including natural numbers, simple fractions, and decimals;

- Understand and use addition, subtraction, multiplication, and division, as well as discover numerical patterns and determine unknown numbers in simple formulae;
- Calculate with natural numbers mentally and by using written calculation methods and pocket calculators;
- Have basic spatial understanding and recognize and describe some of the important properties of geometrical figures and shapes; and
- Compare, estimate, and measure length, area, volume, angles, quantities, and time as well as use drawings and maps, read and interpret data in tables and diagrams, and make use of some elementary Cartesian coordinates.

By the end of the ninth year of compulsory school, the "goals to be attained" section of the syllabus states that students should have acquired the knowledge in mathematics needed to describe and solve theoretical problems as well as solve application problems that occur regularly in the contexts of home and society. The latter skills are needed as a foundation for further education in mathematics. Within this framework, students should be able to do the following:

- Develop their understanding of numbers to include whole and rational numbers in fraction and decimal form;
- Estimate and calculate with natural numbers, numbers in decimal form, percentages, and proportions using mental computation as well as written calculation methods or technical aids;
- Use methods, measuring systems, and instruments to compare, estimate, and determine length, area, volume, angles, quantity, points in time, and time differences;
- Reproduce and describe important properties of common geometrical objects and interpret and use drawings and maps;
- Interpret, compile, analyze, and evaluate data in tables and diagrams;
- Use the concept of probability in simple random situations; and
- Interpret and use simple formulae, solve simple equations, and interpret and use graphs for functions describing real relationships and events.

Science Curriculum in Primary and Lower Secondary Grades

The common syllabus, written from a natural science perspective, together with the syllabi for the specific subjects, constitute a meaningful whole, whose parts support and complement each other.[17] Together, the different parts form the national plan for education in the sciences. Earth Science is taught within the science subjects of chemistry and physics as well as within the social science subject of geography. Overall, science studies are linked to knowledge in other school subjects.

The natural sciences have developed as a result of man's need to find answers to those issues concerning existence, life and forms of life, and our role in nature and the universe. The natural sciences are thus a central part of the Western cultural tradition. The natural sciences can stimulate man's fascination and curiosity with nature as well as make it understandable. Natural science studies satisfy the desire to explore nature and provide opportunities for the joy of discovery. Science education aims to make scientific results and methods accessible, and contributes to society's efforts to create sustainable development and develop concern for nature and man. At the same time, it develops knowledge and views that resonate with the common ideals of both the natural sciences and democracy, including openness, respect for systematic investigation, and well-founded arguments.

In terms of "goals to aim for" when teaching science, the syllabus states that schools should aim to ensure that students develop the following:

- Belief in and ability to see patterns and structures that make the world understandable and strengthen this ability through oral, written, and investigatory activities;
- Insight that science is a specific human activity forming part of our cultural heritage;
- Ability to see how human cultures influence and transform nature;
- Ability to see inter-relationships between observations and theoretical models;
- Knowledge of how experiments are performed on the basis of theories and how this in turn leads to changes in theories;
- Concern and responsibility when interacting with nature;

- Ability to use scientific knowledge and experiences as a basis for examining personal views; and
- Critical and constructive attitudes toward reasoning and showing respect and sensitivity to the views of others.

In terms of "goals to be attained," the syllabus states that students should obtain knowledge and skills in the following areas by the end of the fifth year of compulsory school:

- Nature and Man—Have knowledge within some scientific areas (biology, chemistry, physics, earth science) and be familiar with narratives about nature found in our own culture and other cultures.
- Scientific Activity—Be able to carry out simple systematic observations and experiments, as well as compare predictions with actual results; be familiar with some episodes in the history of science and use this familiarity to gain insight into different ways of explaining nature; and gain insight into different ways of understanding nature through science using systematic observations, experiments, and theories, as well as through approaches used in art, literature, myths, and sagas.
- Use of Knowledge—Have knowledge of how human curiosity about scientific phenomena has led to social progress; have knowledge of managing resources in everyday life and about practical measures for conserving resources; and gain insight into how arguments about everyday environmental and health issues can be developed using personal experiences and scientific knowledge.

By the end of the ninth year of compulsory school, the "goals to be attained" section of the syllabus posits that students should obtain tknowledge and skills in the following areas:

- Nature and Man—Have knowledge of the universe, the Earth, life, and human development; gain insight into how matter and life are studied at different levels of organization; and have knowledge of the cycles of nature and the flow of energy through different natural and technical systems on the earth.
- Scientific Activity—Have knowledge of the scientific method as well as the ability to present knowledge, observations, and conclusions in written and oral form; gain insight into the interaction between the development of concepts, models, and theories as well as experiences from investigations and experiments; gain insight into how knowledge of nature has developed and how this has both shaped and been shaped

by human perceptions of the world; and gain insight into different ways of making nature understandable through science using systematic observations, experiments, and theories as well as by approaches used in art, literature, myths, and sagas.

- Use of Knowledge—Gain insight into the difference between scientific statements and statements based on values; be able to use knowledge of nature and Man and his activities as arguments for issues concerning the environment, health, and inter-personal relationships; be able to provide examples of how science can be used to create better living conditions, but also how science can be abused; and gain insight into the consequences of different aesthetic views on environmental issues.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

In line with Sweden's very decentralized education system, municipalities and schools are free to make their own decisions about the length of the school year and teaching arrangements.

The school year is divided into two semesters and should comprise between 178 and 190 school days (Monday–Friday). The timetable, which forms part of the Education Act and as such has been adopted by Parliament, guarantees each student a minimum of 6,665 hours of instruction in compulsory school (Grades 1–9). The timetable also specifies the number of hours for each subject.[18] The municipalities and the schools themselves decide on the distribution of instructional time across the nine years of compulsory education; however, there should be at least 900 hours of total mathematics instruction and 800 hours of biology, chemistry, physics, and technology instruction over these nine years. The sciences (biology, chemistry, and physics) are taught either as an integrated subject or as three separate subjects. In the 2010–11 academic year, approximately 87 percent of ninth grade students received grades in separate science subjects.[19]

Instructional Materials, Equipment, and Laboratories

The teachers themselves choose teaching methods (including assigning homework to students), topics to be covered in lessons (within the framework of the syllabus, the local school plan, and the school's work plan), and teaching materials. Teachers are free to select materials such as books, audiovisual materials, and ICT, limited only by financial constraints. The schools purchase the teaching materials from various publishers and distribute them to students free of charge.

Use of Technology

The syllabus in mathematics stipulates that the school should aim to ensure students develop their ability to use pocket calculators and computers. Beginning in fifth grade, students must be able to use calculators.

Many schools and municipalities have the goal of a one-to-one computer to student ratio, and continue to invest in this goal. Although most schools have access to computers, Internet, and other technological aids, the use of technology varies widely, depending on teacher interest and financial resource availability at each school. There is approximately one computer per every six students in public compulsory school and one computer per every 4.5 students in independent compulsory schools. In secondary public schools, there is approximately one computer per every 2.5 students and one computer per every 1.6 students in independent secondary schools. Various types of pedagogical computer programs for language development or mathematics are available for all grade levels. In preschool, there are also computer programs for working with images, sound, and video. Schools are not obliged to offer distance learning. At the lower grades of compulsory school, the most common computer programs are available for training in language awareness, reading, writing, and mathematics.[20]

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Between 1988 and 2001, there was no specialized training for teachers of the lowest grades of compulsory education. Instead, teacher education programs prepared teachers to teach either at Grades 1–7 or Grades 4–9. Education programs for teachers of Grades 1–7 focused on either mathematics and science or Swedish and social studies. Teachers of Grades 4–9 could specialize in one of three subjects: mathematics and science, Swedish and foreign languages, or social studies. In 2006, specialization in teaching Swedish and mathematics for Grades 1–3 became mandatory for teachers of Grades 1–6, meaning that these teachers are now specifically trained to teach mathematics in the first three grades. However, teachers who chose to specialize in Swedish and social studies (i.e., not in mathematics and science) are generally not trained to teach mathematics and science in Grades 4–7.

Homework Policies

Sweden has no system-wide policy on homework. Teachers choose whether or not to assign homework, as they deem appropriate.

Teachers and Teacher Education

Public school teachers are municipal employees, while teachers in independent schools are employed by the schools. Teachers without appropriate qualifications may be employed for a maximum of twelve months if qualified staff is not available. This temporary contract may be renewed if qualified staff is still not available when the contract ends.[21]

Teacher Education Specific to Mathematics and Science

Teacher education provides a high degree of individual choice with regard to the combination of subjects studied. Because of the general decentralization of the education system, universities have a high degree of freedom in arranging education programs in accordance with the framework established by the government. For the compulsory education level, teacher education takes 3.5–5 years, with teachers of older students receiving longer training than teachers of younger students. All teacher education includes a supervised teaching practicum.

Municipalities and independent schools are responsible for professional development, the scope of which is determined locally.

Requirements for Ongoing Professional Development

In recent years, there have been various campaigns to increase teachers' education level and professional standing. In 2008, an initiative was introduced to increase the number of teachers with research experience. Teachers were offered the opportunity at ten different universities to participate in a two-year post graduate program in several subjects, including mathematics, science, technology, environmental studies, and geography.[22] In 2007, a campaign called Continuing Professional Development Program for Teachers (*Lärarlyftet*) was introduced. This project aims to raise student achievement levels by improving teacher competence. Teachers were given the opportunity to deepen their competence in subjects for which they already had a degree, as well as broaden their competence in subjects for which they lacked education. The project will be continued in 2012–15, though only for teachers with a teaching degree who are currently teaching subjects or grade levels that they did not study when they earned their degree. The National Agency for Education has organized these courses in cooperation with universities, and municipalities can receive government grants that help cover the costs of the reduced teaching hours of teachers who attend these courses.[23]

Monitoring Student Progress in Mathematics and Science

Sweden monitors and assesses students in compulsory school through a system of national tests, diagnostic materials, and written reports with individual development plans and grades. Designed by the National Agency for Education, the national tests provide support for teachers in monitoring student progress according to the curriculum and syllabus. The tests also provide support for teachers in assigning grades and applying the curriculum and syllabus.

In 2009, national tests were introduced in Grade 3 (in the subjects of Swedish or Swedish as a second language and mathematics), in addition to the already existing national tests in Grade 5 (in the subjects of Swedish or Swedish as a second language, mathematics, and English) and Grade 9 (in the subjects of Swedish or Swedish as a second language; mathematics; English; and biology, physics, or chemistry). The National Agency for Education also provides diagnostic materials, tests, and individual test items that are intended to highlight individual student strengths and weaknesses, help teachers monitor student progress, and make impartial judgments. These materials are available for Swedish (and Swedish as a second language), mathematics, and science for Grades 1–3, English for Grades 1–6, and foreign language and mechanics for Grades 7–9.

Each local school decides how to assess progress in different subjects. For mathematics, a number of schools use standardized screening tests to determine the general achievement level of the school (usually in the middle grades, e.g., Grades 4 or 5), or to identify students with difficulties in the lower grades. Teachers also are free to use other tests if they employ a diagnostic teaching model.

At least once a semester, students and their parents receive progress reports and meet with teachers to discuss student progress and how learning can be stimulated and supported (development dialogues). These progress reports are regulated by law. These meetings are a subsitute for annual progress reports or grading until Grade 8, but they continue throughout compulsory school.

Since 2006, teachers also are required to establish an individual development plan in cooperation with the student and his or her parent(s), describing what the student should strive to achieve. This plan is then evaluated and revised at student-parent-teacher meetings.

Grade promotion in compulsory school is automatic, and students are not required at any point to pass examinations before being promoted to the next level. Grades are awarded from the eighth year of compulsory school onward and reflect student achievement relative to national goals and grading criteria stated in the syllabus for each subject. Grades are given on a three-grade scale: Pass (G), Pass with Distinction (VG), and Pass with Special Distinction (MVG). The levels are related to national criteria established by the Swedish National Agency for Education. A student who does not achieve the goals stated in the syllabus does not receive a grade in that subject, but instead receives a written assessment.

Impact and Use of TIMSS

Sweden's results in TIMSS and other international and national studies indicating declining student achievement have undeniably influenced the general school debate, and have also had an impact on the extensive new school reforms currently taking place.

The Technology Delegation (*Teknikdelegationen*) is a more concrete example of the impact of TIMSS. Though the project concluded in 2010, it conducted outreach work, implemented a campaign, published background reports, organized conferences, and took an active role in the media and through debates to promote greater interest in mathematics, science, engineering, and ICT.[24]

Another example is the MST Initiative 2009–11 (*Regeringsuppdraget att utföra utvecklingsinsatser inom matematik, NO och teknik*), which was initiated by the government to improve mathematics, technology, and science teaching and increase student achievement and interest in these subjects. The project was divided into two sub-projects: one focusing on science and technology and one focusing on mathematics, the Mathematics Initiative 2009–11 (*Matematiksatsningen 2009–11*). Both projects were administered by the Swedish National Agency for Education. Within the Mathematics Initiative, the Swedish National Agency for Education distributed government grants to municipalities and independent schools to develop mathematics teaching. The project involved more than 200,000 students and almost 12,000 teachers.[25, 26] Within the science and technology sub-project, the Swedish National Agency for Education organized professional development for science and technology teachers, supported science centers and organizations to provide professional development for science and technology teachers, and developed teaching supports for these subjects.

The government will continue allocating grants to develop projects that will improve teaching in mathematics, science, and technology, as well as promote higher interest among students in these subjects.

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Syrian Arab Republic

Omar Abouawn
Ministry of Education

Introduction

Overview of the Education System

Education in the Syrian Arab Republic is centralized, and the Ministry of Education is responsible for supervising and setting the curriculum as well as the goals of teaching, including the interaction and integration of active teaching elements (i.e., teachers, students, and curricula).[1] The ministry also is responsible for providing educational services to its 14 directorates in the provinces. Each education directorate is responsible for the schools in its province. The ministry produces new curricular support materials that provide information about various teaching methods.[2] Participation of students' families is an important educational element emphasized in the curriculum.

According to the 2006–07 censuses, 98 percent of schools in Syria are public, 1.8 percent are private, and 0.2 percent are United Nations Relief and Works Agency schools for children who are refugees. Preschool is offered to children ages 3–5, but is not compulsory. The Ministry of Education has built, and is still building, new kindergartens, and it encourages the private sector to build kindergartens.

Since 2002, the constitution of the Syrian Arab Republic has emphasized the right of each child to a free and compulsory education from Grades 1–9. By making education available to all citizens without exception according to their will, abilities, and tendencies, the constitution emphasizes the principles of democratization of education and equality of opportunity.[3] The Compulsory Education Law No. 35 of 1981 made education compulsory for all Syrian children and their peers (e.g., Palestinians living in Syria) from Grades 1–6.[4] As of 2002, Basic Education Law No. 32 has combined elementary and primary education into one basic stage, making it compulsory from Grades 1–9. This stage ends in a government examination, after which successful students are granted a Certificate of Basic Education. The bylaws of Basic Education Law No. 32 specify both the organization and the specific properties of the basic education stage. At the same time, they specify the terms of basic education and help to overcome any obstacles that may hinder application of the law. The bylaws were amended in 2004 based on feedback from educators in the field and defined the cycles of basic education as follows:

- First Cycle (Grades1–4)—Those who teach in this cycle are mainly single class teachers (tutors). Assistant teachers also teach subjects such as art, music, English, science, and mathematics. Teachers who are university graduates also may teach students in this cycle when needed.
- Second Cycle (Grades5–9)—Those who teach in this cycle are specialist teachers, assistant teachers, and basic education tutors (who have a Bachelor of Arts degree).

Secondary education in Syria includes three grade levels. Students who are in the ninth grade of basic education (the final year of the second cycle) have the option of attending public secondary school if they pass the government examination at the end of basic education with a score of at least 60 percent. In the first year of secondary school, students study both scientific and literary topics; but, in their second year, students choose to specialize in either the scientific or the literary domain. The scientific domain focuses on topics such as mathematics, physics, chemistry, biology and Earth science. The literary domain focuses on topics including geography, history, philosophy, and languages (English and French). Arabic is taught in both domains.

After the third year of secondary school, students take a national comprehensive test. Based on the student's score, there are different options for university study. Students specializing in the scientific domain scoring approximately 98 percent on the national test can study scientific research or medicine at the university level. Students scoring approximately 95 percent can study pharmacy or dentistry; students scoring approximately 90 percent can study electrical engineering, mechanical engineering, or civil engineering; students scoring approximately 85 percent can study architecture after an additional test and interview; and students who score approximately 60 percent on the national test can study general science or mathematics. These percentages differ each year, according to need.

Students specializing in the literary domain also have different options for university study based on their national examination scores. Students scoring at least 95 percent on the national exam can study journalism or law. Taking into consideration the score a student gets on the portion of the examination covering the language he or she wishes to study, students scoring 90 percent can study languages such as Arabic, English, French, Spanish, or Japanese. Students scoring approximately 85 percent can study history, geography, and philosophy, while students scoring approximately 60 percent can study athletics or any other major.

Languages of Instruction

According to the latest census in 2010, the population of Syria was about 23 million. In 2005, 18.7 percent of the population could not read or write. According to the constitution, Arabic is the official language in the Syrian Arab Republic, with education being provided mainly in Arabic. English is taught as the primary second language from the first grade of the basic learning stage, and French is taught in addition to English in Grades 7–12.

Mathematics Curriculum in Primary and Lower Secondary Grades

Developing and revising the pre-university mathematics curriculum, based on fieldwork by teachers and educational supervisors who consult with curriculum specialists in foreign countries, is an ongoing process for the Ministry of Education. Fundamental change in the mathematics curriculum began in 1997 with Grade 1 and by 2006 was extended to Grade 12. In 2005, mathematics and pedagogy experts from schools and universities in Syria established curriculum standards based on international standards for mathematics.

The mathematics curriculum at the First Cycle (Grades 1–4) of basic education aims to develop skills in mathematics. The curriculum also aims to develop and encourage mathematical skills and knowledge by focusing on the following content domains:

- Types of numbers (ordinals, cardinals, and fractions) and how to use them in arithmetic problems;
- The relationship among numbers (including fractions), comparisons of numbers, the spatial value of counting, and number forms (but not ordinal counting);
- The interpretation of numbers, including interpreting the meaning of numbers and fractions in different contexts, such as measurements and quotients;
- Mental arithmetic and evaluation;
- Arithmetic processes, including the meaning of the process (when to add and when to subtract), and the relationship between arithmetic processes (multiplication and addition, multiplication and division, and addition and subtraction);

- Measurement procedures and systems; and
- The use of diagrams and pictograms to classify, categorize, and organize data, including the concept of scale.

The aims of the mathematics curriculum for the end of the Second Cycle (Grades 5-9) of basic education are that students will be able to recognize and understand the following:

- The concept of a set and the relationship between an element and the set, and how to employ this relationship when classifying elements into sets (e.g., the set of cardinal numbers, the set of integers, and the set of whole numbers);
- The relationship between two sets of numbers and the characteristics of each set;
- The concepts of order and equivalence of sets;
- Algebraic symbols and how to use them to solve mathematical problems;
- Properties and characteristics of two- and three-dimensional geometric shapes, and how to think about and discuss geometric shapes;
- Location and position, and how to describe parallel relations using coordinates;
- Data and probability, including collecting, organizing, and presenting data; presenting conclusions and expectations based on data; and understanding basic principles of probability and its applications;
- Problem solving, including building mathematical knowledge;
- Use of mathematical concepts and skills to solve everyday problems and to make estimates; and
- Use of mathematical language to express and find solutions to everyday problems.

In addition, by the end of eighth grade, students are specifically expected to be able to do the following:

- Understand the concept of proportion;
- Perform operations with proportions;
- Use equations to solve everyday problems;
- Use diagrams and statistical data tables;

- Apply numerical facts related to everyday life;
- Apply proofs by contradiction to solve everyday problems;
- Perform mathematical operations and express results accurately;
- Employ arithmetic operations; and
- Master mathematical skills to succeed in the workplace.

Science Curriculum in Primary and Lower Secondary Grades

Developing the science curriculum in the basic and pre-secondary stage has been an ongoing process, and one of the main goals of the Ministry of Education. In the late 1980s, the ministry began to write and compile science textbooks. However, these efforts lacked a clear vision. Since 1994, the initiative has become a priority, and a new science curriculum was developed and evaluated in the 2003–04 school year. The new curriculum concentrated on developing scientific thinking skills and was considered effective.

The curriculum standards established in 2005 describe the skills and basic principles of science that should be taught and learned at school through the eighth grade. These standards outline educational objectives regarding content, methodology, evaluation, and the educational environment. The ministry aims for students to learn and become proficient in the following:

- Scientific knowledge, including scientific facts and principles and basic scientific concepts;
- Basic scientific processes or skills; and
- Understanding of the real world.

With regard to scientific knowledge, students learn to understand the different types of functional scientific knowledge. Concepts and facts presented in biology, geology, physics, and chemistry enable students to understand the relationship among these areas of science, to deal with science in a comprehensive way, and to recognize different phenomena. Basic scientific concepts are taught in two overarching subject areas—biology and geology, and physics and chemistry. Biology and geology topics include the following: species of animals from the local environment; differences and similarities between animals and plants and between vertebrates and invertebrates; and land and the environment, including an understanding of environmental balance, fossils, the age of the Earth, and geological durations. Physics and chemistry topics include the concepts of electromagnetism, light, and chemical reactions.

Basic scientific processes or skills refer to observation, measurement, deduction, classification, investigation, drawing conclusions, reasoning, prediction, diagram interpretation, and experimentation. These skills enable students to observe, think, meditate, experiment, investigate, and discover rather than receive and memorize information.

Understanding of the real world can be achieved by developing an appreciation for the greatness of nature and its conservation, an understanding of relationships between people and the environment, and preventative health methods. In this framework, the concepts of science, distributed across grade levels, are as follows:

- The First Cycle (Grades 1–4)—Know the parts of the body; recognize plants and their shapes; describe animal habitats; describe human body changes and development; recognize the sources of sounds and the relationship between sounds and hearing; be interested in the cleanliness of the body, home, class, and school; explain the role of trees in protecting the environment; appreciate the importance of water and air for humans, animals, and plants; understand the relationship between force and action; and be aware of the existence of objects in outer space.
- The Second Cycle (Grades 5–9)—Classify organisms into kingdoms and understand how organisms grow, including the role of cell assimilation, reproduction, and principles of heredity; understand renewable and non-renewable resources; learn about the importance of rocks in nature, learn about the structure of the ecological system and the biosphere and the changes that have occurred throughout Earth's history; learn the structure of the atom; know the role of carbon in organisms; determine the relationship between force and motion in nature; and understand the effects of electric current.

From Grades 1–6, one book is used to teach general science (biology, physics, chemistry, and earth science), and a single assistant teacher or tutor teaches the subject. In Grades 7–9, biology is taught from one textbook, while physics and chemistry are taught from separate textbooks, and specialized teachers teach each subject.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

The Ministry of Education sets the instructional plan for each subject. For example, science and health are allotted three teaching periods per week in Grades 1–7 and four teaching periods per week in Grades 8 and 9. There are four teaching periods per week for mathematics in Grades 1–8.

Instructional Materials, Equipment, and Laboratories

Recently, the most important educational development in Syria was the Ministry of Education's efforts in 2005 to adopt measurable, high-quality, international standards regarding the teaching and learning process. The ministry has emphasized quality in pre-secondary education by defining target goals that are parallel to international views about what students should know and be able to do in all learning stages, so that students will have learning skills equal to those of students in developed countries. In order to choose the most suitable textbooks for students in the fields of science and mathematics, the Ministry of Education asked for offers from different publishers and then formed an evaluation committee to study the textbooks and choose the best among them. However, this experience was not successful enough, so the Ministry of Education, using international standards as models, created its own national standards and textbooks edited by science and mathematics specialists working in the ministry.

In the Syrian Arab Republic, teaching materials include all equipment, tools, and techniques used by teachers to convey educational knowledge to students in the classroom and develop teaching processes that fulfill the goals of teaching. Within the Ministry of Education, directorates are responsible for development and dissemination of educational techniques as well as the design and production of teaching methods that comply with the curriculum. The directorate in charge of teaching methods holds professional development courses for teachers, tutors, supervisors, technicians, laboratory workers, and librarians in the following areas:

- Using teaching methods;
- Developing teaching methods for science and mathematics that make use of simple, readily available materials; and
- Using and maintaining advanced laboratory equipment.

The Ministry of Education produces educational lessons and television programming in coordination with the Directorate of Curriculum and Supervision and the Directorate of Informatics, in compliance with the curriculum. In 2006, a Syrian educational television channel was founded. The channel, supervised by a ministry directorate, helps promote literacy and spread educational awareness among different sectors of society by enriching the knowledge of teachers, learners, and masters as well as developing their skills in information technology.

Use of Technology

The world is witnessing a knowledge revolution accompanied by the development of information technology in all areas of life. Thus, in Syria, there has been a need to coordinate national plans for curriculum development and computer or information science. This has resulted in a focus on information science in conjunction with the adoption of new, modern pedagogical methods in education.

The Ministry of Education, through the Directorate of Informatics, is working on implementing training courses in information science for workers at the central administration and sub-directorate, in accordance with the training plan for reinforcing students learning experiences. It also is working on linking both branches of secondary schools with the ministry's technological network and providing all schools with email service and Internet access.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Those who teach in the Second Cycle, from Grade 5 to Grade 9, are specialist teachers.

Homework Policies

There are no formal policies regarding homework or the amount of homework assigned to students. However, in general, students are given some homework after each lesson in addition to homework and projects at the end of each unit (a unit consists of several lessons). Students in the first cycle of basic education do not have a significant amount of homework, especially those in the first and second grades. However, the amount of homework increases in the second cycle, as well as in secondary education.

Teachers and Teacher Education

Teacher Education Specific to Mathematics and Science

In order to become qualified as a mathematics or science teacher, teacher candidates must complete a teacher education program consisting of three main modules:

- Module One—Academic preparation within their field of scientific specialization.
- Module Two—Professional preparation, including educational and psychological studies that enable the teacher to organize curricular strands and create learning experiences for students that facilitate the process of learning science.
- Module Three—General education preparation.

In order to work as a teacher of mathematics and science, a degree from a teacher education college or certificate verifying that one is a teacher is required. Teachers also may have a university degree in mathematics and science, together with a diploma in pedagogy. Candidates for public school positions are chosen based on their graduation grades and a merit-based competition, which includes testing and a personal interview.

Requirements for Ongoing Professional Development

New teachers must attend professional development courses throughout the academic year and during summer vacations. These are ongoing courses, covering scientific content as well as effective teaching methods in science and mathematics.

The Ministry of Education also has created a committee of head teachers and supervisors. These individuals receive training in methodology as well as structural evaluation and diagnosis in order to provide specialization in these fields and to improve their performance. The specialized supervisors also provide teachers with training on contemporary, active methodologies and on recent scientific and mathematical discoveries.

The ministry is revising a professional development program for teachers in accordance with recent trends in virtual and remote teaching. The program is associated with training used for similar programs that have been successful in other countries.

The ministry has a project that promotes and prepares teachers to teach the new curriculum and integrate the use of technology in education through a system of open learning within the Ministry of Higher Education. The training project provides professional development for nearly all teachers through an ongoing process. In the 2004–05 school year, the project served 7,809 teachers; in the 2005–06 school year, 8,079 teachers; and in the 2006–07 school year, 8,500 teachers. The project also served 1,695 pre-service teachers who needed diplomas in pedagogy via Internet learning in association with the Syrian Virtual University.

Monitoring Student Progress in Mathematics and Science

Assessment in Syria is an organized, focused, and planned process that includes evaluating student strengths and weaknesses. The process of assessment is comprehensive and includes three types of educational goals—cognitive, intuitive, and professional.

The school year is divided into two terms. The Ministry of Education determines how the curricular topics are distributed across the terms, as well as when terms begin and end. During each term there are oral tests, training and assignments, and monthly tests (written, oral, or performance based, according to the nature of the subject and the standard of the class). For Grades 1–4, a student is promoted to a higher grade if he or she achieves the required scores. A student fails if he or she is weak in Arabic Language, or if he or she fails in two or more subjects.

For Grades 7–8, the following tests and examinations take place during each term:

- Oral and performance-based tests and written assignmentsA student's class grade for each term is based on his or her average score on oral and performance-based tests as well as on written assignments. This grade is a weighted average, with oral tests accounting for 25 percent of the score, homework assignments and related activities accounting for 25 percent, and written tests accounting for 50 percent. This weighting applies to all subjects with the exception of English language, which has a different grading scheme.
- End of term examinations—These examinations, whose timing is determined by the ministry, last six days and consist of oral and written sections in each of the fields studied.

A student's final grade for the school year in each subject is calculated by averaging the student's class grade and end-of-term examination score. The average of these scores at the end of the two terms is the final grade. The student passes and is promoted to the next grade by fulfilling the following conditions:

- The collective final grade for all subjects is at least 50 percent;
- Final grades in each subject are not less than 40 percent; and
- The final grade in Arabic language is not less than 50 percent.

At the end of ninth grade, students take a general test to earn the Basic Learning Certificate. This is a comprehensive state examination administered at the national level. For tenth grade, the required score to advance is higher than in ninth grade and determined by the ministry. At the end of twelfth grade, students take a general state examination at the country level to gain entry to a university. Each university individually determines the score required to enter that university. Therefore, the score that a student earns on the state examination is important and determines whether the student may continue to university.

Impact and Use of TIMSS

Participation in TIMSS has improved methods of teaching, learning, and testing in the Syrian Arab Republic and continues to inspire further development. Syria's participation in TIMSS has had a positive influence on educational policies and reforms. Previously, tests included traditional questions dependent on memorization. Currently, however, test questions require students to apply, analyze, and synthesize information. The new curricula in general, and the mathematics, physics, biology, and chemistry curricula in particular, are based on current teaching and learning methods as well as new ways of testing, requiring higher-order cognitive skills (analyzing, synthesizing, and evaluating).

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Thailand

Precharn Dechsri

The Institute for the Promotion of Teaching Science and Technology

Introduction

Overview of the Education System

The national government of Thailand includes 19 ministries, with the Ministry of Education being responsible for the oversight of education. The provision of education can be categorized into three types: formal education, non-formal education, and informal education.

Formal education includes two levels: basic education and higher education (see Exhibit 1). The National Education Act (B.E. 2545) mandates nine years of compulsory education consisting of six years of primary schooling and three years of lower secondary schooling.[1] Primary school enrollment age begins at about the age of seven.

Exhibit 1: Formal Education Structure in Thailand

Education Level		Number of Years	Grades
Basic Education	Preprimary Education	3	Kindergarten 1–3
	Lower Primary Education	3	Grades 1–3
	Upper Primary Education	3	Grades 4–6
	Lower Secondary Education	3	Grades 7–9
	Upper Secondary Education	3	Grades 10–12
Higher Education	Postsecondary Education, including diploma, high vocational certificate, and bachelor's degree	4–6	

The 1999 Education Act introduced changes into Thailand's education system, decentralizing the education provision authority. As a result, the Ministry of Education has structured the educational services administration into three levels: national level, educational service areas, and educational institutions. At the national level, the Ministry of Education is responsible for curriculum development and implementation. The Ministry of the Interior also plays a role in providing education through two educational bodies: the Department of Education, Bangkok Metropolitan Administration and the

Bureau of Local Educational Development and Co-ordination, within the Department of Local Administration.

Thailand's educational service areas include two levels: primary educational service areas, of which there are 183; and secondary educational service areas, of which there are 42. Each educational service area has an Area Committee for Education, which is responsible for approximately 200 educational institutions with student populations of 300,000 to 500,000.

At the educational institution level, each school is responsible for its own administration and management relating to budget, personnel, and general academic affairs. Oversight is through a seven- to fifteen-member board consisting of representatives of parents, teachers, community groups, local administration organizations, alumni, and academics. Educational budgeting and allocation are provided by local administration organizations.

The Office of Non-Formal and Informal Education within the Ministry of Education administers non-formal education in Thailand. The office is responsible for providing education for the out-of-school population through non-formal educational centers nationwide. Informal education is still in its initial stages of development and is not yet widespread.

Languages of Instruction

Located in Southeast Asia, Thailand has a population of 65.4 million—32.1 million men and 33.3 million women.[2] The official language of Thailand is Thai, which is the language of instruction in regular classes and schools throughout the country. English is one of the foreign languages provided in the curriculum; other foreign languages include French, Chinese, and German. Moreover, English is also permitted as the language of instruction in some schools.[3]

For international schools, other languages may be used in classes. These schools primarily provide instruction for children accompanying their parents who work in Thailand, though other children may also attend.

Mathematics Curriculum in Primary and Lower Secondary Grades

In 2008, the *Basic Education Core Curriculum B.E. 2551*[4] was adopted as a framework and to provide direction for curriculum development and teaching in educational institutions. The Ministry of Education has entrusted the Institute for the Promotion of Teaching Science and Technology (IPST) to develop mathematics and science curricula for the basic educational level. The mathematics curriculum developed by IPST is described in detail in the *Basic Education Curriculum B.E. 2551*.[5] This document establishes a framework for basic learning time allocations which can be adjusted to suit school contexts and learner situations. The mathematic curriculum prescribes the following learning time allocations, as shown in Exhibit 2.

Exhibit 2: Learning Time per Year for Mathematics at Each Educational Level

Educational Level	Hours/Year
Lower Primary: *Prathom* 1–3 (Grades 1–3)	200
Upper Primary: *Prathom* 4–6 (Grades 4–6)	160
Lower Secondary: *Mattayom* 1–3 (Grades 7–9)	120
Upper Secondary: *Mattayom* 4–6 (Grades 10–12)	240

At the primary level (Grades 1–6), the mathematics curriculum covers six learning areas: number and operations, measurement, geometry, algebra, data analysis and probability, and mathematical skills and processes. The core topics in the mathematics curriculum at this level include the following: [6]

- Number and Operations—Whole numbers, fractions, decimals up to three decimal places, and percentage and operations with percent; develop number sense; properties of numbers; and problem solving involving addition, subtraction, multiplication, and division of whole numbers, fractions, and decimals up to three decimal places.
- Measurement—Length, distance, weight, area, volume, capacity, time, money, direction, maps, sizes of angles, and problem solving involving measurement.
- Geometry—Characteristics and properties of triangles, quadrilaterals, circles, cubes, cylinders, cones, rectangular prisms, pyramids, angles, and parallel lines.
- Algebra—Patterns and relationships, and problem solving involving patterns; and writing equations, and solving linear equations.
- Data Analysis and Probability—Data collection; data discussion from picture graphs, bar charts, pie charts, line graphs, and tables; data presentation in picture graphs, bar charts, and line graphs; and applying basic concepts of probability to estimate the possibility of events.
- Mathematical Skills and Processes—Problem solving.

The core topics in the mathematics curriculum for the lower secondary level (Grades 7–9) include the following:

- Number and Operations—Ratios, proportions, percentages, and exponentiation with integer exponents; square roots and cube roots of real numbers; estimation in number operations; and problem solving.
- Measurement—Surface area of rectangular prisms and cylinders, and volume of rectangular prisms, cylinders, pyramids, cones, and spheres; and using appropriate measurement methods and units for determining length, area, and volume.
- Geometry—Properties of congruent triangles and similar triangles; parallel lines; the Pythagorean theorem; and geometric transformations.
- Algebra—Patterns and relationships in patterns; and analyzing mathematical situations and problems using one-variable equations, systems of two-variable linear equations, one-variable linear inequalities, and graphs.
- Data Analysis and Probability—Data collection and presentation using pie charts or other appropriate data representations; and probability of events and measures of central tendency (mean, median, and mode) for ungrouped data.
- Mathematical Skills and Processes—Problem solving.

Science Curriculum in Primary and Lower Secondary Grades

As with mathematics, the *Basic Education Core Curriculum B.E. 2551*[7] prescribes a framework for basic learning time allocations for science, which can be adjusted to suit school contexts and learner situations (see Exhibit 3).

Exhibit 3: Learning Time per Year for Science at Each Educational Level

Educational Level	Hours/Year
Primary: *Prathom* 1–6 (Grades 1–6)	80
Lower Secondary: *Mattayom* 1–3 (Grades 7–9)	120
Upper Secondary: *Mattayom* 4–6 (Grades 10–12)	240

The science curriculum covers eight learning areas: living things and living processes, life and the environment, matter and properties of matter, force and motion, energy, processes that shape the earth, astronomy and space, and the nature of science and technology. Core topics of the science curriculum for the primary level (Grades 1–6) include the following:[8]

- Living Things and Living Processes—The structure and function of various systems in living things.
- Life and the Environment—Relationships among diverse living things in different environments.
- Matter and Properties of Matter—Properties and classification of materials; states of substances, properties of substances, and the causes of changes in substances; substances in daily life; and simple methods for separation of substances.
- Force and Motion—Consequences of applying forces on objects, pressure, and basic principles of buoyancy.
- Energy—Properties and basic phenomena of light, sound, and electric circuits.
- Processes that Shape the Earth—Characteristics, components, and properties of the Earth's surface and the atmosphere.
- Astronomy and Space—Relationships between the sun, the Earth, and the moon that affect natural phenomena.
- Nature of Science and Technology—Relationships among science, technology, and society; boundaries of science; and scientific reasoning, ethics, morals, and values.

Core topics of the science curriculum for the lower secondary level (Grades 7–9) include the following:

- Living Things and Living Processes—Characteristics and main components of cells; functions of various systems of organs; and heredity.
- Life and the Environment—Biotechnology; diversity of organisms; and behaviors of organisms and their responses to stimuli, and relationships among organisms in the environment.
- Matter and Properties of Matter—Components and properties of solutions; pure substances, and changes of substances in terms of change of states; formation of solutions; and chemical reactions.
- Force and Motion—Friction; moments of force; motion in daily life; the law of conservation of energy; transfer of energy; heat equilibrium; reflection, refraction, and intensity of light.

- Energy—Relationships among electrical quantities; principles of electronic circuits and home circuitry; and electrical energy.
- Processes that Shape the Earth—Processes that cause changes in the Earth's crust; geological resources; factors affecting atmospheric changes, and interactions within the solar system and effects on various things on Earth; and the importance of space technology.
- Astronomy and Space—Solar systems, and interactions in the solar system; phenomena in the sky; and space technology.
- Nature of Science and Technology—Relationships among science, technology, and society; boundaries of science; and scientific reasoning, ethics, morals, and values.

Instruction in Mathematics and Science in Primary and Lower Secondary Grades

Several projects have been initiated to support the teaching and learning of mathematics and science to high-achieving students, enabling their continued study of science and technology at university. These projects include the Development and Promotion of Science and Technology Talent project, specialized science schools, the Science Classrooms in University-Affiliated Schools project, and the Special Science Classroom project.

The Development and Promotion of Science and Technology Talents project (DPST)[9] is a joint collaboration of the Ministry of Education, the Ministry of Science and Technology, and the Institute for the Promotion of Teaching Science and Technology (IPST). The project aims to build a strong human resource base specialized in science and technology by developing talented students in these areas and supporting them to reach their full potential.

Specialized science schools include Princess Chulabhorn's College and *Mahidol Wittayanusorn* School.[10] Princess Chulabhorn's College is a group of secondary schools overseen by the Ministry of Education, established to provide education for students with special interest in scientific fields. Currently the group consists of twelve schools distributed among all of the educational service areas throughout the country. Dedicated as regional science schools, they have the following objectives:

- Increase opportunity for students throughout the country who are talented in mathematics and science, emphasizing opportunity for the needy in each region;

- Provide education needed to develop a sufficient number and quality of human resources in science, technology, and innovation to develop the nation by carrying out research and development for knowledge creation and innovation; and
- Act as model to stimulate the development of high quality mathematics and science teaching and learning.

Mahidol Wittayanusorn School is an upper secondary school specially designed to provide education for exceptionally gifted and talented students in mathematics and science, and to enable them to pursue their interest in learning mathematics and science to their full potential. The school functions as a public organization under the supervision of the Ministry of Education.

The Science Classrooms in University-affiliated Schools project promotes the creation of science classrooms in schools under the supervision of a university.[11] Initiated by the Ministry of Science and Technology, the project aims to advance the country through supporting the provision of higher education for upper secondary school students who wish to become researchers in science and technology. The project currently matches seven pilot schools with universities, who work closely together to develop and administer a "Science Classroom" curriculum.

The Special Science Classroom project[12] is a joint collaboration of the Office of the Basic Education Commission, the Office of the Higher Education Commission, the Office of the National Science and Technology Development, and the Institute for the Promotion of Teaching Science and Technology (IPST). The project aims to accelerate the development and support of mathematics and science talent through specially designed curriculum and supplementary activities such as the following: science camps; field trips with researchers; mathematics-, science-, and technology-based projects; and the promotion of academic work at the provincial, regional, and national levels. Since its inception in 2007, IPST has been tasked with teacher development for this project. To date, a total of 207 schools have participated in the project.

Instructional Materials, Equipment, and Laboratories

Learning media serve as support tools in the learning process, enabling students to efficiently acquire knowledge, skills, processes, and characteristics as prescribed in the curriculum standards. Learning tools come in various forms, sources, and channels; they may include print media, in- and out-of-school learning resources, resource persons, and science laboratories.

Use of Technology

The *Basic Education Core Curriculum B.E. 2551*[13] suggests the use of electronic media for teaching and learning in mathematics and science education. These include computer-assisted instruction, software, the Internet, e-books, graphing calculators, and radio and television programs. It is recommended that the provision and application of learning media correspond to the curriculum and learning objectives. In addition, the design and coordination of learning activities should use material that is accurate, up-to-date, appropriate, and suitable to the developmental levels and learning processes of students.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Presently, Thailand's education policy does not require teachers to have educational degrees corresponding to the subjects they teach. However, at the lower secondary level, schools are required to have teachers accredited in mathematics and science. At the moment, the Teacher's Council of Thailand is moving toward reforming regulations on teaching licenses, stipulating that teachers must hold subject-based licenses, and that secondary teachers may only be permitted to teach those subjects related to their academic majors. The planned reform will take effect in 2013.[14]

Homework Policies

Thailand has no policy on homework. However, the *Basic Education Core Curriculum B.E. 2551*[15] suggests that homework should be assigned as part of classroom assessment. This assessment can be done either by teachers, students themselves, classmates, or parents, in order to monitor the learning progresses of students in all subjects.

Teachers and Teacher Education

Teacher Education Specific to Mathematics and Science

The second report of the Office of the Higher Education Commission (OHEC), *Long Range Plan on Higher Education (2008–2022),*[16] claims that the quality of secondary students who pursue higher education has regressed as a result of teacher quality. OHEC has decided that new conditions must be established to attract talented applicants into the teaching profession. For example, proper training will be provided to graduates of majors other than education who wish to enter the teaching profession. OHEC has therefore increased its efforts to review the production and development of teachers for schools and vocational colleges and has launched the New Breed of Teacher Production and Development program.[17] Currently, the following measures are taking place:

- Adjusting the processes of teacher education, recruitment, remuneration, and welfare to attract quality personnel who are interested in the teaching profession (e.g., by providing scholarships and civil-service-job placement guarantees);
- Supporting research at higher education institutes on issues regarding the teaching profession, as well as establishing a system of guarantees to ensure the quality of teachers and teacher education institutes;
- Planning teacher education, development, and deployment systematically, and coincident with need;
- Supporting graduates of non-education majors who are interested in becoming teachers to realize their potential as teachers, and allowing local community member involvement in teaching and learning development; and
- Developing an education system for teachers at the higher-education level, enabling the linkage of teaching ability, knowledge transfer, and management with professional development experience.

Currently, Thailand has two programs for educating professional teachers: a five-year bachelor's degree program and a one-year certificate program. Details are as follows:

- Five-year bachelor's degree program—This program is for basic education teachers (Grades 1–12) and comprises four years of coursework and one year of internship in an educational institution. The scope of the program includes teaching, research in classroom settings, curriculum development in schools, learner development activities, school service, and community education and services. A teaching license is conferred upon graduation.
- One-year certificate program—This professional development program is open to bachelor's degree graduates of any major who wish to pursue teaching as a profession. In this program, participants complete a teaching practicum at a certified school for one year. A teaching license is conferred upon successful completion of the program.

Requirements for Ongoing Professional Development

The New Breed of Teacher Production and Development program was also initiated to support in-service teachers in various aspects of their profession, including knowledge of content, learning activities, and student assessment. The Office of the Higher Education Commission has its own project to develop new teacher development as well, with the aim of improving student learning outcomes in Thailand.

The following guidelines currently support and stimulate in-service teachers in their professional development:[18]

- Promoting training and seminars continuously to increase teacher skills in learning activities;
- Promoting the establishment of a research fund to develop teacher knowledge and pedagogical innovations;
- Providing a means to recognize and honor outstanding teachers;
- Upgrading the teaching profession by adjusting the salary scheme; and
- Developing a teacher assessment system that is linked to student learning outcomes.

Among many projects to develop mathematics and science teachers, a distance teacher education program has been initiated with the cooperation of the Institute for the Promotion of Teaching Science and Technology, the Office of the Higher Education Commission, the Office of the Basic Education Commission, and the Education Television Station.[19] The objectives of the program are to develop greater teacher efficiency in knowledge of content, teaching techniques, and learning activities. The program also aims to train certain science, mathematics, and computer teachers to become master teachers and advisors to other in-service teachers.

The Office of Teacher Civil Service and the Educational Personnel Commission are in charge of the teacher academic ranking process. As part of the teaching, professional development, and educational quality development programs, the offices have established a ranking classification based on various merit categories, including professional knowledge and experience and ethical standards. Currently, the classification system is divided into four levels with the following qualifications:[20]

- New Teacher—Teachers who have less than six years' experience and who hold a four-year bachelor's degree.
- Professional Teacher—Teachers who have a minimum of six years' experience, hold a four-year bachelor's degree, a two-year master's degree, and have met evaluation criteria.

- Senior Professional Teacher—Teachers who have been rated as senior professional teachers for at least one year and have met evaluation criteria.
- Expert Teacher—Teachers who have been rated as expert teachers for at least three years, have at least five years' experience as senior professional teachers, and have met evaluation criteria.

Teacher advancement is determined by evidence such as a report on equipment used in learning activities, lesson plans, student behavior and achievement, a self-assessment report, and an assessment by the educational institution. To be considered for a rank increase, teachers must submit documents demonstrating their teaching performance and academic output to the Educational Personnel Commission. Once approved, an allowance corresponding to the academic ranking is granted in addition to the basic salary.

Monitoring Student Progress in Mathematics and Science

Thailand uses assessment results to improve the quality of student learning and to evaluate the attainment of learning goals in order to ensure that students achieve the required learning standard.[21] There are four levels of assessment: classroom assessment, educational institution assessment, educational service area assessment, and national assessment.

The objective of classroom assessment is to monitor the learning development of students in all subjects taught to determine the effectiveness of learning and teaching activities and identify needed improvements. Teachers also may use classroom assessment to improve their teaching methods. Classroom assessment may be conducted in various ways: asking questions, observing, checking homework, evaluating projects or assignments such as portfolios, and using tests. This type of assessment may be conducted by teachers themselves or may take the form of student self-assessment, peer assessment, or parent assessment.

The objectives of educational institution assessment are to monitor the learning development of students in all subjects on an annual or semester basis, evaluate institutional effectiveness in providing education, and identify any needed improvements. Results may be used for local and national comparisons. They may also inform the development of new policies, curricula, projects, learning activities, development plans, and the reporting of various aspects of education to related agencies and parents.

The objective of educational service area assessment is to evaluate the quality of students in a designated service area, according to the standard of the core curriculum. The Local Assessment System for students of Grades 2, 5, 8, and 11 in all schools within educational service areas previously covered five subjects: mathematics, Thai, English, social sciences, and science. The recently addition of health and physical education, art, and careers and technology, has expanded the system to cover eight subjects. Results from the standardized Local Assessment System can be used as data for education quality development in an assessed area.

The objective of national assessment is to assess the academic proficiency of students in Grades 3, 6, 9, and 12 nationwide, according to the learning standard of the core curriculum.[22] Results from the tests will be used as data to benchmark education quality at several levels for the benefit of educational and national policy development. The two agencies responsible for the national assessment are the Bureau of Education Testing, within the Ministry of Education, and the National Institute of Educational Testing, which conducts a number of tests including the following:

- The National Test—This assessment is undertaken by the Bureau of Education Testing, within the Ministry of Education. It aims to assess students of Grades 3, 6, 9, and 12 and use the data as quality indicators to determine development trends. The assessment focuses on evaluating student academic knowledge, synthesis, and problem solving according to the basic education curriculum. The subject assessed by the National Test are indicated in Exhibit 4.

Exhibit 4: Details and Areas of Learning in the National Test

Areas of Learning	Grade 3	Grade 6	Grade 9	Grade 12
Thai	x	x	x	x
Mathematics	x	x	x	x
English		x	x	x
Science		x	x	
Work and Career		x		
Social Sciences			x	x
Physics				x
Chemistry				x
Biology				x

- The Ordinary National Educational Test (O-NET)—This assessment is undertaken by the National Institute of Educational Testing. It is administered to students of Grades 6, 9, and 12, and covers eight subjects: Thai, social sciences, foreign languages, mathematics, science, health and physical education, art, and work and career.
- The General Aptitude Test—This assessment is undertaken by the National Institute of Educational Testing. It aims to assess the capabilities for university admission of students in Grade 12 and above. The test is divided into two major sections: the first section covers reading, writing, critical thinking skills, and problem solving skills; and the second section covers the ability to communicate in English.
- The Professional and Academic Aptitude Test—This assessment is undertaken by the National Institute of Educational Testing. It aims to measure basic student knowledge in their chosen professional field of study as well as their potential for success. The assessment covers seven areas of proficiency: mathematics, science, engineering, architecture, education, fine and applied arts, and foreign languages.

Impact and Use of TIMSS

Based on the TIMSS 2007 results, the executive committee of the Ministry of Education passed a resolution addressing issues related to the reading, writing, and analytic thinking skills of Thai students at both the primary and secondary school levels. As a result, assessment and development projects for mathematics and science teachers were initiated in 2011. A central strategy of these projects has been to categorize teachers according to their capability into three levels—high, middle and low—in order to provide more appropriate and focused teacher education. Those classified in the high level group will serve as master teachers and those at the middle level will be trained to strengthen their knowledge and skills, while the low level group will be re-trained in all areas.

The Ministry of Education's *Second Decade of the National Education Reform (2009–2018)* has set as its strategic goal the raising of the quality of education in Thailand to a higher international standard. In addition, a goal has been set to increase the mathematics and science scores in the Program for International Student Assessment (PISA) to be on par with the international average, using 2003 and 2006 scores as benchmarks.

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Tunisia

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Introduction

Overview of the Education System

In Tunisia, education is recognized by the constitution as a fundamental right guaranteed to all citizens regardless of gender, social origin, ethnicity, or religion.[1] This right is asserted by the Law of Education Orientation, which stipulates that "the State provides free education to all those who are of school age, and gives all students equal opportunity to enjoy this right."[2, 3]

Public education is a service provided by the national government and managed by the Ministry of Education. Private schools, which are not managed by the ministry, also operate within the framework of the national education system. Educational objectives, teaching programs, and textbooks are established nationally. As with all disciplines, the ministry defines the mathematics and science programs and curricula, and all schools are obliged to implement them.

Preschool education is for children ages 3–6 and takes place in private and public establishments. Although not compulsory, preschool is the responsibility of the Ministry of Education. The objective of preschool education is to prepare students for the first cycle of basic education (primary education). Preschool education prepares students for community life and promotes the development of oral communication, the senses, psychomotor capabilities, and a healthy perception of one's body.

Primary and secondary education comprises two stages: basic and secondary education. Basic education lasts nine years, is compulsory from ages 6–16, and is divided into two cycles:

- First cycle takes place in primary schools, lasts six years (Grades 1–6), and includes children ages 6–12; and
- Second cycle, or preparatory cycle, takes place in lower secondary schools, lasts three years (Grades 7–9), and includes children ages 13–16.

Secondary education occurs in upper secondary schools and lasts four years (Grades 10–13). At the end of the first year of secondary education, students are directed to specialized subject areas, such as science and technology.

Parents also tend to urge their children to specialize in these areas. The policy goals of the national government with regard to specialized subject areas are to do the following:

- Encourage 70 percent of students to specialize in scientific and technological areas; and
- Increase the opportunities for study in these areas, both in secondary school and at the university level.

Since Tunisia's independence in 1956, there have been three major reforms of the Tunisian education system, the most recent of which was in 2002. In an effort to provide a quality education to everyone and prepare students to play an active role in society, the 2002 reform focused on modernizing schools and all aspects of education—programs, teacher education, educational methods, evaluation, school management, and school life.

Languages of Instruction

Tunisia's official national language is Arabic. In basic education, Arabic is the language of instruction for all subjects except computer science, which is taught in French. In secondary school, all science subjects are taught in French.

For historical reasons, French is an important language in Tunisia, and students begin learning French in Grade 3. English is taught as the second foreign language, beginning in Grade 6.

Mathematics Curriculum in Primary and Lower Secondary Grades

Exhibits 1 and 2 present the mathematics curriculum for Grades 1–2 and 3–4 in basic education in Tunisia. The processes in mathematics education in these grades focus on the following: knowing facts and procedures using whole numbers; understanding the meaning of addition, subtraction, and multiplication; and solving problems related to daily life using numbers, measurement, and geometrical figures.

Exhibit 1: Mathematics Curriculum, Grades 1–2

Content Area	Objectives and Expectations
Numbers	Read, write, represent, and compare whole numbers from 0 to 999; Add and subtract with whole numbers from 0 to 999; Identify sets of numbers according to common properties; and Use mental computing strategies.
Geometry	Identify the relative positions of objects in space, on lines, and on closed curves; and Identify and draw polygons according to the number of their sides.
Measurement	Use whole numbers to measure length, volume, mass, time, and money.
Algebra	Identify a common property of a set of elements, classify objects according to common properties, and count the number of elements in a set; and Use shapes, patterns, and models to classify objects or find an unknown quantity.

Exhibit 2: Mathematics Curriculum, Grades 3–4

Content Area	Objectives and Expectations
Numbers	Read, write, represent, and compare whole numbers from 0 to 999; Add, subtract, and multiply with whole numbers; Divide numbers within multiplication tables and find the quotient and remainder in the division of two integers; and Use mental computing strategies.
Geometry	Use geometric diagrams; and Identify and draw the following using rulers and right angles: acute, obtuse, and right angles; perpendicular and parallel lines; and squares and rectangles.
Measurement	Use whole numbers to measure length, volume, mass, time, and money; and Find the perimeter and area of squares and rectangles, and figures made up of squares and rectangles, and make estimates of area.
Algebra	Use shapes or models to find an unknown quantity.
Data	Read, select, and organize data presented in tables and graphs.

Exhibit 3 presents the mathematics curriculum for Grades 5–6 in basic education. The processes in mathematics education for these grades focus on the following: knowing facts and procedures using whole, decimal, and rational numbers; understanding the meaning of the four arithmetic operations; reasoning about shapes; solving problems using numbers; proportionality, measurement, and the properties of two- and three-dimensional figures; and providing a link between everyday language and mathematical language.

Exhibit 3: Mathematics Curriculum, Grades 5–6

Content Area	Objectives and Expectations
Numbers	Compute with whole and decimal numbers using the four arithmetic operations; Compute with rational numbers using addition, subtraction, and multiplication; Compute with equivalent fractions, scales, and percentages; Identify and compare whole, decimal, and rational numbers; and Use mental computing strategies.
Geometry	Use geometric diagrams; Identify and draw acute, obtuse, and right angles, perpendicular and parallel lines, squares and rectangles, circles, and symmetric figures to a given line of symmetry; Construct a two-dimensional representation of a three-dimensional solid; Construct perpendicular and parallel lines; Construct triangles, squares, and rectangles according to their geometrical properties; and Identify complementary and supplementary angles.
Measurement	Measure length, area, angles, volume, mass, time, money, and velocity; and Find the perimeter and area of figures made up of squares, rectangles, triangles, trapezoids, and circles.
Algebra	Use shapes or models to find an unknown quantity.
Data	Read, classify, and select data from tables or shapes; and Organize and represent data in bar graphs, pictograms, and diagrams.

The processes in mathematics education in Grades 7–8 focus on the following: knowing facts and procedures; using integers, decimals, and rational numbers; understanding numerical concepts; reasoning using deduction and induction; working mathematically; solving problems using numbers, proportionality, measurements, and properties of two- and three-dimensional figures; and using mathematical language. Exhibit 4 presents the mathematics curriculum for Grades 7–8 in basic education.

Exhibit 4: Mathematics Curriculum, Grades 7–8

Content Area	Objectives and Expectations
Numbers	Compute with integers, decimals, and rational numbers using the four arithmetic operations; Use prime numbers and common factors, compute multiples, and compute powers of numbers; Find square roots using a calculator; and Compare, estimate, and round numbers.

Content Area	Objectives and Expectations
Geometry	Identify, measure, compare, and construct angles involving adjacent angles, vertical angles, complementary and supplementary angles, angle bisectors, alternate angles, corresponding angles, interior angles between parallel lines, and angles of special triangles or special quadrilaterals;
	Find the distance between two points, from a point to a line, and between two parallel lines;
	Recognize and identify congruent triangles;
	Identify and construct special triangles, special quadrilaterals, and circles according to their geometric properties;
	Construct a figure symmetric to a given line or point of symmetry; and
	Find and use the Cartesian coordinates of a point in two dimensions.
Measurement	Calculate length, volume, mass, time, money, and velocity;
	Find the perimeter, area, or volume of figures made up of squares, rectangles, triangles, trapezoids, circles, cubes, prisms, pyramids, cones, and spheres using geometrical properties, scale, or proportionality; and
	Measure angles using geometric properties.
Algebra	Use letters to represent numbers;
	Compute with simple algebraic expressions; and
	Solve simple linear equations.
Data	Collect, classify, and summarize data in tables and statistical diagrams; and
	Read, interpret, and make predictions using statistical diagrams.

Science Curriculum in Primary and Lower Secondary Grades

Science instruction in Grades 1–6 emphasizes understanding concepts. In earth science and biology, students should be able to characterize living organisms according to their different methods for obtaining nutrients, respiration, and reproduction. They also should be able to identify some diseases and understand how to prevent them. In environmental science, students should recognize some factors that disrupt environmental balance and know some methods for protecting the environment. In physics and chemistry, students are expected to recognize devices that can be used to measure time. They also are expected to recognize the different states of matter and the conditions that cause matter to undergo a change of state. They should know the physical properties of air and identify different types and natural sources of energy.

In Grades 7–8, the processes of science education focus on the following: understanding chemical and physical concepts, understanding the relationships between organisms, understanding how systems function, making observations and conducting experiments, reasoning and drawing conclusions, working scientifically, and solving problems related to students' environments.

The content of the science curriculum in Grades 7–8, focuses on investigating and understanding basic principles and concepts related to the following:

- Matter, including physical properties (e.g., density and concentration); chemical properties of solids, liquids, and gases; and the symbols of some basic elements and formulas used in simple chemical reactions;
- Light, including reflection, refraction, and the spectrum;
- Electricity and magnetism, including electric current, circuits, motors, and generators;
- Common elements in the environment and the relationships between these elements;
- The life cycles of plants and animals, including reproduction;
- The mechanisms of photosynthesis and respiration in plants; and
- The structure and function of the human nervous, respiratory, and circulatory systems.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

The latest (2002) reform of the Tunisian education system led to a curriculum emphasizing science, languages, and vocational training. Information and communications technology is integrated at all educational levels in order to promote reasoning, thinking, and problem solving skills.

Instructional Materials, Equipment, and Laboratories

Primary schools do not have science laboratories. However, they do have the minimum required equipment for science instruction. Lower secondary schools have well-equipped science laboratories.

Use of Technology

There is no official policy regarding calculator or computer use in instruction at the fourth grade. At the eighth grade, students are permitted to use calculators when solving simple problems or operations in class, and teachers are encouraged to use computers when teaching mathematics, though the curriculum does not provide specific content for this purpose.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Since the 2007–08 school year, primary school teachers teach all subjects, while lower secondary school teachers are specialists and teach only mathematics, chemical and physical science, or environmental science.

Homework Policies

Tunisia has no official policy regarding homework.

Teachers and Teacher Education

Teacher Education Specific to Mathematics and Science

Primary school teachers are managed by the Primary Education Department of the Ministry of Education, while secondary school teachers are managed by the ministry's Secondary Education Department. Teacher education (in term of both theoretical and practical aspects) in mathematics and science is monitored by mathematics or science inspectors from the ministry.

To be qualified as a primary teacher, prospective teachers must first complete a three-year university degree (BA or BSc). Students who have obtained a university degree and want to become primary school teachers also must pass a written examination given by the Ministry of Education before completing a one-year training program in an academic institute.

To be qualified as a secondary school teacher, students must complete a three- or four-year university degree. Students who have a university degree in mathematics and want to become mathematics teachers must pass a written examination given by the ministry. Students also must pass an oral examination, and those who succeed are recruited as lower- and upper-secondary school teachers. Prior to beginning their formal teaching careers, these recruits are required to participate in a three-week summer program (50 hours) focusing on their subject of specialization as well as information and communication technologies.

Requirements for Ongoing Professional Development

Since 2003, the Tunisian Ministry of Education has been reforming teacher professional development to provide teachers with more autonomy and to enhance their role in the educational process.[4] The reformed system aims to provide teachers with opportunities to develop reflective skills, consolidate mathematical knowledge, become informed about new pedagogical tools, collaborate with other teachers, and participate with other educational staff in improving the school's role in society.

Mathematics professional development is compulsory for all primary school teachers and occurs throughout the year. It represents 30 percent of total teacher professional development and is staffed by primary education inspectors. Mathematics professional development focuses on mastering disciplinary concepts aligned to the curriculum, problem-solving strategies (especially for problems related to everyday situations), assessment procedures, and the mathematics teaching and learning process. Specific topics concerning pedagogical approaches and technology use are integrated into general professional development.

Professional development for secondary school teachers occurs throughout the year and is staffed by inspectors. Every two weeks, one eight-hour day is reserved for professional development, and every teacher must attend a total of six days of professional development annually. In addition, a one- to three-week summer program is offered for teachers who are interested in specific professional development (e.g., in their subject discipline, information and communication technology, pedagogy, or didactics). To update and increase the depth of teacher knowledge, a professional development curriculum is produced every year focusing on changes in the mathematics or science curriculum and textbooks.

Monitoring Student Progress in Mathematics and Science

At the end of Grade 6, students may take an optional examination. Students who perform exceptionally on this examination may then continue their studies in a special lower-secondary school for outstanding students. Similarly, after completing basic education (at the end of Grades 9), students may take another optional examination; students who succeed on this examination receive a certificate allowing them to continue their studies in a special upper-secondary school for outstanding students.

At the end of upper-secondary education (Grade 13), students take the National Baccalaureate Examination (*Examen National du Baccalauréat*), the content of which consists of six subjects. Each examination subject is assigned a weight depending on the student's course of study, and the average of these weights determines the student's exam grade. Students who pass the baccalaureate can enter the university, while those who do not pass enter the workforce or study at a private school.[5]

Impact and Use of TIMSS

Article 52 of the Education Act of 2002 defines the objectives of teaching mathematics and science, and new programs were implemented to achieve these objectives.[6] Student performance in these subjects is expected to improve as a direct outcome of these changes, and subsequent TIMSS and PISA studies will be used to verify if this expectation is realized.

Based on the performance of Tunisia's students in TIMSS 1999 and 2003, physics is now taught in Grade 7 in lower-secondary schools.

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Turkey

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Introduction

Overview of the Education System

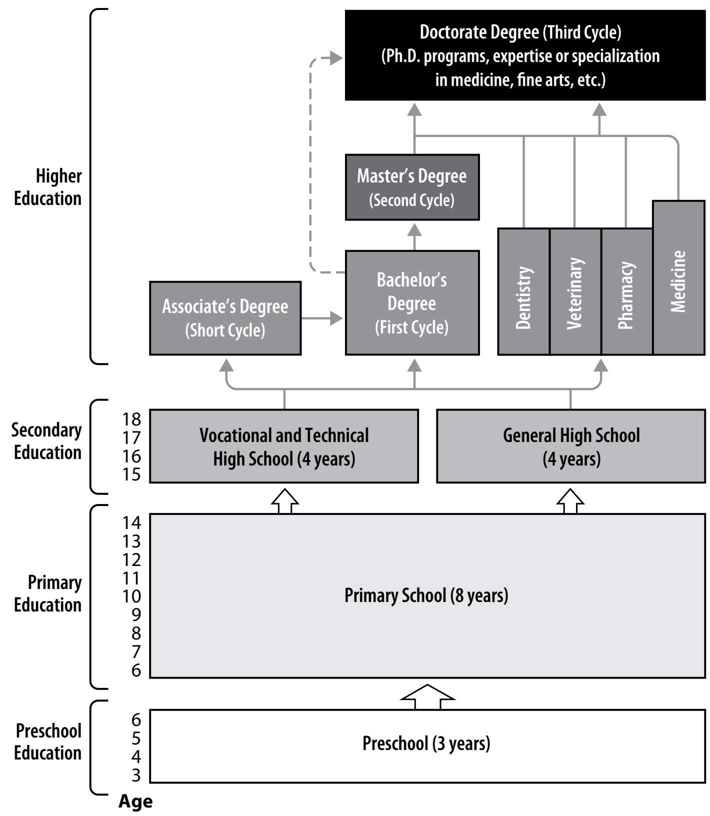
In Turkey, the National Ministry of Education is responsible for planning, programming, advancing, monitoring, and inspecting all educational and training services and activities.[1] The basic structure of the Turkish national education system comprises preschool education, primary education, secondary education, and higher education (See exhibit 1).

Preschool education (ages 3–6) is not compulsory. The objective of preschool education is to ensure that children accomplish the following: develop physically, mentally, and emotionally; acquire good habits; and prepare for primary education. Children in preschool who come from disadvantaged backgrounds are provided with an environment that fosters learning at the same level as their more advantaged peers, and teachers ensure that all children speak Turkish correctly.[2]

Primary education (ages 6–14) lasts for eight years, is free of charge, and is compulsory for all citizens. The goals of primary education are to enable students to acquire the basic knowledge, skills, and attitudes necessary to prepare them for higher education and for life. Graduates of this stage receive primary education diplomas. In 2011, there were 32,797 primary schools in Turkey, of which 898 (2.7%) were private schools. That same year, there were 10,981,100 primary school students (51.2% boys and 48.8% girls) and 503,328 teachers total across public and private schools.[3]

Secondary education (ages 15–18) lasts at least four years and is not compulsory. Any student has the right to attend secondary education at public schools free of charge after completing primary education. In Turkey, high schools are of two types: general high schools and vocational and technical high schools. General high schools accept students based on scores on

Exhibit 1: The General Structure of the Turkish Educational System



general tests or performance examinations and may have a focus area, such as mathematics and science, social studies, sports, or the arts. High schools with specific focuses include Anatolian high schools (where the curriculum places more emphasis on learning English and mathematics), science high schools (where the curriculum places more emphasis on learning science), and Anatolian teachers high schools (where the curriculum places more emphasis on learning English and pedagogy). Vocational and technical high schools provide education and training leading to different careers. These schools also may accept students based on a general test score if more students apply than the schools can accommodate. Although the curriculum differs according to the specific purposes of each type of school, the goals of secondary education are to provide students the following: a common, minimum, overall knowledge; familiarity with the problems of the individual and society and the ability to seek solutions; awareness that will contribute to the socioeconomic and cultural development of the country; and preparation for higher education, a profession, life, and employment, according to their interests and aptitudes.

Universities provide higher education for a fee to students who hold high school diplomas. Most programs last four years, although the required number of years differs according to the program of study. The purpose of higher education is to train future workers within a system of contemporary educational and training standards to meet the needs of the country. As such, the system provides high-level specialized education in various fields.

In 1963, the Scientific and Technological Research Council of Turkey (TUBİTAK) was established as an autonomous institution to advance science and technology, conduct research, and support Turkish researchers. This council also is responsible for promoting, developing, organizing, conducting, and coordinating research and development according to national priorities and targets. It acts as an advisory agency to the Turkish government on science and research issues and reports directly to the prime minister.[4]

In 1995, the Science Centers Foundation was established in Turkey.[5] The foundation seeks to increase society's knowledge about social and applied sciences and to create an environment that encourages enthusiasm for learning, provides opportunities to conduct exciting experiments, and fosters the joy of discovery. The foundation also is responsible for strengthening communication between industry, schools, and society, and organizes specific projects, contests, workshops, and exhibitions. Members of the Science Centers Foundation include the National Ministry of Education, the Scientific and Technological Research Council of Turkey, the Turkish Academy of Sciences (TÜBA), and many non-profit and non-governmental organizations, as well as several universities.

Although there is no explicit emphasis on mathematics or science in Turkish education, basic competencies in mathematics and science and related educational policies have been promoted since the revision of primary and secondary school curricula in 2004. In accordance with these national policies, science high schools now play an important role in encouraging students to pursue careers in mathematics, science, and technology. The goal of science high schools is to give students the necessary background in mathematics and science so they can enter university engineering and technical programs and pursue careers in mathematics and science. Students who want to attend science high schools must pass the Entrance Examination for Secondary Schools at the end of eighth grade. Mathematics and science are given considerably more importance in the curriculum of science high schools compared to the curriculum of other high schools. In the 2010–11 school year, there were 300 science high schools in Turkey—141 public and 159 private schools.[6]

Lastly, the National Ministry of Education establishes and manages Science and Arts Centers (*Bilim ve Sanat Merkezleri*) designed to provide additional support to talented pupils and students from primary and secondary schools. By providing such supplementary education, these centers enable students to endeavor to reach key targets of personal success.

Languages of Instruction

According to the Turkish Constitution, Turkish is the official language of the country. Therefore, in primary and secondary education, all instruction is offered in Turkish.

Mathematics Curriculum in Primary and Lower Secondary Grades

The vision of the current primary mathematics curriculum emphasizes educating students to use mathematics in their lives, solve problems, share their solutions and ideas, and enjoy learning mathematics.[7] The principle "every child may learn mathematics" is the main focus of the curriculum, which includes many essential and contemporary teaching goals, elements of constructivism, and other teaching theories. Although not explicitly stated, the intended curriculum is based on constructivist principles, student-centeredness, and a departure from lecturing, moving instead toward understanding, exploring, and conceptualizing the essence of mathematical ideas.[8]

The curriculum highlights the importance of a learning environment where students may research, discover, and solve problems, and where they can share and debate their solutions and approaches. The curriculum promotes connecting various areas of study within mathematics as well as interconnecting mathematics with other subjects and disciplines. In addition, the topics covered have been prepared according to the developmental level of students for each class. These strategies are intended to enhance students' active participation in learning mathematics and its principles.

The current mathematics curriculum follows a conceptual approach that uses students' experiences to help them comprehend and consider abstract mathematics concepts. Through projects and homework, this approach is intended to enable students to express their individual differences and abilities. Students are encouraged to use various activities to conduct research, obtain results, and discuss their solutions, and to use different materials for these activities to develop their psychomotor abilities. The mathematics curriculum highlights conceptual and procedural understandings throughout primary school.[9] The curriculum emphasizes fundamental mathematical abilities, such as problem solving, reasoning, communication, and making connections along with general skills, such as creative thinking, research-based learning, and technology use.

In the current curriculum, there are four learning areas for Grades 1–5: numbers, geometry, data, and measurement. While the actual distribution of this content differs slightly for each grade, Exhibit 2 presents each of these learning areas and its overall content across this grade span.[10]

Exhibit 2: Mathematics Curriculum Learning Areas and Content, Grades 1–5

Learning Areas	Content
Numbers	Use numbers and digits; develop estimation and operation abilities by understanding the four arithmetic operations; associate fractions, percentages, and decimal fractions; and determine relations within patterns and apply this information to problem situations.
Geometry	Develop spatial abilities; determine relationships between geometric shapes and objects; decorate with planar shapes; understand and use symmetry; and use geometric tools and materials.
Data	Gather, organize, and analyze data (probability is taught beginning in the fourth grade).
Measurement	Perform estimations; and develop an understanding of the concepts of measurement.

There are five mathematics learning areas for Grades 6–8: numbers, geometry, measurement, probability and statistics, and algebra. Exhibit 3 presents each of these learning areas and its respective content across this grade span.[11]

Exhibit 3: Mathematics Curriculum Learning Areas and Content, Grades 6–8

Learning Areas	Content: Grade 6	Content: Grade 7	Content: Grade 8
Numbers	Natural numbers, integers, operations on integers, multiples and factors, fractions, decimals, percentages, rate and ratio, and sets.	Operations using integers and rational numbers, rates and ratios, and consumer arithmetic.	Exponential numbers, square roots of numbers, and real numbers.
Geometry	Lines, line segments, and rays; angles; polygons; congruency and similarity; transformation geometry; patterns and ornaments; and geometric shapes.	Lines and angles, polygons, congruency and similarity, circles and circular area, geometric shapes, transformation geometry, and patterns and ornaments.	Triangles, geometric patterns and ornaments, geometric objects, geometric transformations, and projection.

Learning Areas	Content: Grade 6	Content: Grade 7	Content: Grade 8
Measurement	Angles, length, area, time, volume, and liquids.	Measuring angles, areas of quadrilaterals, perimeter of a circle and an arch length, area of a circle and sector, surface areas of geometric shapes, and volume of geometric shapes.	Measuring triangles, volumes of geometric objects, and surface areas of geometric objects.
Probability and Statistics	Probable conditions, main concepts of probability, types of events, preparing survey questions and collecting data, tables and graphics, and measures of central tendency and dispersion.	Probable conditions, types of events, types of probability, tables and graphs, and measures of central tendency and dispersion.	Determining the possible outcomes, types of event charts and graphs, measures of central tendency, and spread.
Algebra	Patterns and relations, algebraic expressions, and equality and equations.	Patterns and relations, algebraic expressions, and equations.	Patterns and relations, algebraic expressions, and equality and equations.

Science Curriculum in Primary and Lower Secondary Grades

In Grades 1–3, general classroom teachers teach a course entitled Knowledge of Life; however, the science content of this course is limited because teaching science is not the course's primary objective. In Grades 4–8, a different course, Science and Technology, is compulsory. General classroom teachers teach Science and Technology in Grades 4–5 and science specialist teachers teach the course in Grades 6–8.

There are seven learning areas in the current Turkish science and technology curriculum for Grades 4–8: [12]

- Physical processes;
- Life and living beings;
- Matter and change;
- The Earth and the universe;
- Science process skills;
- Science-technology-society-environment; and
- Attitudes and values.

The first four of these learning areas represent specific science content, while the latter three areas function as themes that are interwoven with this content throughout the grades. Although the latter three areas are not included in the curriculum as separate units, they are represented in all content area units. The interwoven curriculum design clearly emphasizes the intent of engaging students in student-centered activities.[13] Learning by doing is seen as a central pillar of the new curriculum, the last stage of which was implemented during the 2008–09 school year.

Each of the first four learning areas (i.e., for science content) includes several units, which develop in a spiral fashion through the grades. Exhibit 4 presents a summary of the Science and Technology content areas and their units for Grades 4–8.[14]

Exhibit 4: Science and Technology Content Areas and Units, Grades 4–8

Grade	Physical Processes	Matter and Change	Life and Living Beings	The Earth and the Universe
4	Force and motion Light and sound Electricity in our life	Learning about matter	Solving the puzzle of the human body Let's walk in and explore the world of living beings	Our planet Earth
5	Force and motion Light and sound Electricity in our life	Changes in matter and distinguishing change	Solving the puzzle of the human body Let's walk in and explore the world of living things	The Earth, sun, and moon
6	Force and motion Electricity in our life Light and sound	The particulate structure of matter Matter and heat	Reproduction, growth, and development in living things The systems in the human body	What is the crust of the Earth made of?
7	Force and motion Electricity in our life Light	The structure and features of matter	The systems in the human body Humans and the environment	The solar system and beyond: The puzzle of outer space
8	Force and motion Sound Electricity in our life	The structure and features of matter Phases of matter and heat	Cell division and heredity The relationships between living things and energy	The natural processes

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Mathematics is taught for four class periods (40 minutes each) per week in Grades 1–8. Science and Technology is taught for three periods per week in Grades 4 and 5, and four periods per week in Grades 6–8.

Instructional Materials, Equipment, and Laboratories

Books, periodicals, and other instructional materials, prepared by either the ministry or by private companies, are reviewed and evaluated by a school's board of education, according to specific evaluation criteria. The ministry then purchases approved materials and distributes them free of charge.

Schools typically have science laboratories in their buildings. The current science curriculum is based on student activities, including small experiments and in-class teacher demonstrations, and teachers widely use these strategies in their instruction.

Use of Technology

The ministry's vision for technology is for broadband Internet access and related technologies to be available in all classrooms. Thus, the ministry is allocating resources and launching projects and initiatives to achieve this ambitious goal. Many schools already have some or all of these technologies installed in their classrooms.

The ministry has deployed technology in the following two ways:

- Information and communication technology within schools—There are 29,812 computer laboratories, 159,294 projection devices, 8,267 smart boards, and 851,144 computers available for student use across all Turkish schools. In addition, 97 percent of schools have an Internet connection.[15]

- E-school—In this system, parents, students, teachers, school administrators, and educational specialists can interact with each other using the Internet. For example, students and parents can view report cards for each course at the end of each semester, parents can interact with their child's teachers, and teachers can give students homework.

The mathematics curriculum specifically encourages effective use of technology, and encourages teachers to examine and become familiar with technologies such as calculators, dynamic geometry software, graphing software, algebra software, and web-based and virtual manipulatives.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

In the Turkish education system, schools have subject area specialist teachers for mathematics and science beginning in the sixth grade.

Homework Policies

Projects and homework should support meaningful learning; to this end, the national mathematics and science curricula enable students to express their individual differences and abilities via projects and homework assignments. The ministry has an expectation that teachers use some forms of alternative assessments, such as such as open-ended problems, portfolios and performance assessments, which are seen as important tools to improve education.

Teachers and Teacher Education

Teacher Education Specific to Mathematics and Science

In 2001, after considering the existing requirements for primary teachers implemented according to Law Number 4306, teacher education programs were reorganized to meet the short- and long-term teacher requirements for primary education. Teacher education now takes one of two forms: [16]

- A four-year undergraduate education for preprimary and primary education teachers; or
- A four-year undergraduate education for both primary and secondary education teachers in common subject areas, including foreign languages, music, visual art, physical education, special education, and computer and technology instruction.

Prospective primary school mathematics and science teachers are required to earn a Bachelor of Arts degree from a university department of education and to achieve the necessary score on the Public Servant Selection Examination. After meeting these requirements, the ministry appoints them as teachers.

Requirements for Ongoing Professional Development

In order to provide financial and human resources for teacher professional development, the ministry collaborates with universities, the private sector, and other related public institutions, such as the Scientific and Technological Research Council, the Atatürk Supreme Council of Culture, Language, and History, and the Foreign Language Training Center for Government Officers. When deciding what types of professional development to provide, the ministry considers teacher and school administrator needs as well as new developments in the field. Each year, the ministry's professional development department conducts a needs assessment, selects high priority topics, and develops a professional development plan. The ministry then announces this plan to staff, including teachers and school administrators, on the ministry web page and sends official documents to schools. In addition to the above-mentioned programs, teachers and school administrators have the opportunity to register and participate in some programs via the Internet.

Monitoring Student Progress in Mathematics and Science

The ministry is responsible for assessing student performance in Turkey. The goals of the national assessments are to assess student achievement in a variety of subject areas at several age and grade levels and to identify trends in achievement levels over specific periods of time.

The only national assessment with consequences for individual students is the Student Achievement Level Examination, which is given to eighth grade students transitioning from primary to secondary education. The examination results determine student placement at selected secondary educational institutions, including Anatolian high schools, science high schools, and Anatolian teachers high schools. The examination results also are expected to constitute the greatest data source for showing the knowledge and skills of students in primary education at a national level.[17]

The Student Achievement Assessment Test is another national assessment at the primary level, conducted for the purpose of quality control, in which a randomly selected sample of fourth through eighth grade students are tested in the Turkish language, mathematics, science, social science, English, and computer literacy. The National Ministry of Education has conducted this test every three years since 1992. The results are used to evaluate the academic achievement and intellectual capabilities of students and to develop new policies for improved primary education.

Teachers' primary instructional strategies take advantage of multiple methods and techniques during all stages of teaching and learning.[18] Thus, the current curricula contain a greater number of student assessment instruments compared to previous curricula, and adopt a multilevel, multifaceted measurement and assessment approach to student learning. Teachers are urged to use formative learning assessment and measurement techniques in addition to analytic and holistic evaluation methods, rather than typical paper and pencil tests. Assessment instruments include written examinations, oral examinations, projects, portfolios, journal writing, homework, quizzes, checklists, attitude scales, interviews, observations, posters, exhibitions, peer evaluations, and self-evaluations. Written examinations can include essays, multiple-choice questions, short-answer questions, and matching questions.[19] In addition, using performance assessment, which is both process- and product-oriented, is strongly emphasized; this is done based on the philosophy that students can learn more meaningfully when they are motivated and engaged in their own learning. Teachers are recommended to score assessments based on their professional judgment.

As previously mentioned, all primary and secondary school students are monitored on a semester basis using the e-school system. Through this system, classroom teachers keep all students' academic and personal interests, hobbies, books read, and other pertinent records.

Impact and Use of TIMSS

Turkey participated in TIMSS in 1999 and 2007 at the eighth grade, ranking 31st and 30th in mathematics achievement and 33rd and 31st in science achievement in these years, respectively. TIMSS is one of the international indicators used to monitor Turkish education. Educators in Turkey consider their students' scores and rankings on international assessments important reflections of their teaching, so it can be said TIMSS and other international research projects affect curriculum development and education reforms indirectly.

Suggested Readings

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Ukraine

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Introduction

Overview of the Education System

The public education system in Ukraine is highly centralized, and the responsibilities of the Ministry of Education and Science, Youth and Sport include the following:

- Developing and implementing state educational policies;
- Creating the standards and legislative basis for educational system functioning;
- Developing educational standards and curricula for all subjects studied at secondary school;
- Identifying future possible directions and profiles of school education;
- Specifying the school subjects learned in different profile classes, and compiling syllabi;
- Organizing expertise, certifying course books and learning materials, and providing permission for use of these materials in teaching and learning;
- Providing all public school students with course books and conducting a competition for course book selection;
- Conducting the final state examination and Independent External Assessment Testing, the results of which are mandatory for enrollment in higher educational institutions; and
- Organizing in-service teacher training.

The main documents regulating teaching content are individual curricula for required subjects, which are similar for all educational establishments regardless of their jurisdiction. The national curricula define the "invariant" (i.e., compulsory) content for required subjects. Apart from the invariant content component, a "variant content component" was introduced in 2001; its content is defined locally by individual educational establishments and teachers, but should be relevant to the content of elective or optional course curricula approved at the state or regional levels. The amount of variant content may not exceed 10 percent of total learning time at Grades 5–8, and 20 percent at Grades 10–11.

The curricula for all subjects, and in particular for mathematics and science, are the result of mutual efforts of leading academicians, teachers, and in-service specialists. The Ministry of Education and Science, Youth and Sport regularly holds a competition, and winning curricula are approved by the ministry, become mandatory for all teachers, and form the basis for creating ministry-mandated instructional course materials. The curricula define the content of teaching materials, the amount of teaching, and requirements for students' educational achievement.

The national levels of education in Ukraine are the following:

- Preschool (nursery school), for children ages 3–6;
- Primary school, for children ages 6–10 (Grades 1–4); and
- General secondary education, for children ages 10–17 (Grades 5–11).

Preschool education is carried out in accordance with the national curriculum and focuses on social functioning and, to a certain extent, academic development. Preschool establishments are attended by 75.9 percent of children of the appropriate age. When starting primary school, the overwhelming majority of children have basic skills in reading and prior experience in mathematics (e.g., counting and using numbers to at least 10).

Primary school includes the following subjects: reading, mathematics, and natural history (an integrated subject aimed at developing basic knowledge in a number of sciences). In Grades 5–6, students are taught natural history. Beginning in Grade 6, learning particular science subjects begins with geography; in Grade 7, physics, chemistry, and biology are taught.

General secondary education is mandatory and is divided into middle school (Grades 5–9) and high school (Grades 10–11). General secondary education is provided by the following educational establishments: comprehensive secondary schools, which are the most widespread; specialized schools that offer extensive learning of particular subjects, the majority of which include extensive mathematics or science learning; lyceums or gymnasiums, which provide a higher level of general educational standards; and a small number of boarding schools and schools for children with special needs. Privately funded private schools account for less than 1 percent of all schools. All other schools are state-funded schools which provide free educational services.

Subject Olympiads are important tools that encourage students who display special interest in learning mathematics, science, and technology to pursue careers in these fields. The Olympiads are organized as a unified multilevel system, with competitions at the school, regional, and national levels in the subjects of mathematics, physics, chemistry, biology, and geography.

Ukraine's 2004 Educational Standards regulate the primary and general secondary education syllabus, describe the characteristics of primary and general secondary education content, and specify state requirements at the target level. As a result of implementing these standards, the high school curriculum has been reformed, particularly with the important introduction of profile learning. Since 2010, students in Grades 10 and 11 have been taught in accordance with certain profiles (e.g., courses of study in mathematics, physics, or biology), and different subject curricula and syllabi for various profiles have been developed. Profiles are united into similar educational areas, one of which is mathematics-science. About one-third of all high school students take this profile course of study; in many schools, placement in a profile is conducted as early as middle school.

In 2011, new sets of national educational standards for mathematics and science were developed and approved by the Cabinet of Ministers of Ukraine. On April 20, 2011, Decree No. 462 approved the National Standards of the Comprehensive Primary Education,[1] followed by approval of the National Standards of the Basic and Comprehensive General Secondary Education (Decree No. 1392) on November 23, 2011.[2] The new National Standards of the Basic and Comprehensive General Secondary Education focus teachers on a transition from a learner-centered approach to its practical realization. The new National Standards of the Basic Education will be implemented in Grades 5–9 beginning September 1, 2013, and future assessment of mathematics and science will be conducted in accordance with these new standards and subject curricula.

The achievement component of each educational area within the National Standards defines the required student outcomes relevant to subject content and competencies (i.e., a learner is aware of, understands, uses, and exhibits and analyses his or her thoughts or attitudes). During secondary general education, students are expected to acquire subject-specific knowledge. In addition, as a result of the integrated, inter-disciplinary curriculum, students also are expected master the following key competencies with respect to personal-social and intellectual growth: the ability to learn; communicating in the official, native, and foreign languages; competence in mathematics, and basic competencies in science and technology; information competence; social and civic competencies; general cultural competence; and competence in entrepreneurship. Considering the necessity to improve national healthcare for the successful development of the country, one additional key competency was added—competence in health improvement. All competencies are complex and are developed on an interdisciplinary basis within each educational area.

The major changes in the sphere of teaching Mathematics and Science were triggered by recent fundamental social transformations in Ukraine. Humanitarian, cultural, and pragmatic components of mathematics and science have gained new emphasis, with the focus on students' general intellectual and cultural development. The current goals of this area are finding a balance between academic and social aspects in teaching mathematics and science, as well as developing new standards for school outcomes.

Languages of Instruction

The official language in Ukraine is Ukrainian, which also is the language of instruction for all subjects except foreign languages in about 85 percent of all schools.[3] Russian is the largest minority language in Ukraine, comprising nearly 6 percent of schools. A small number of other national languages are the language of instruction for nearly 2 percent of schools each. However, often the language of instruction is not the students' native language. For example, students whose native language is Russian often take courses in which Ukrainian is the language of instruction, and vice versa. In most cases, this does not hinder comprehension because almost all of Ukraine's population is bilingual, with children starting to use at least two languages in preschool.

Mathematics Curriculum in Primary and Lower Secondary Grades

For primary and middle schools, the required knowledge and skills in mathematics are defined by the National Standards and are interpreted in the relevant subject syllabi, which specify the target learning goals, the content of learning materials, and requirements for student achievement in mathematics.

The goal for learning mathematics in primary school is the development of mathematical competence as well as the key competencies necessary for students' self-realization in a rapidly changing world. The successful achievement of this goal requires the following (though, in schools with an extensive mathematics program, these requirements may be more challenging):

- Developing students' readiness to identify problems that can be solved with mathematical methods, solve extended word problems, think logically, justify actions, and perform actions according to an algorithm;
- Developing students' ability to use correct mathematical language, symbols, and graphic information; solve shape and space problems; use numerical skills in everyday situations and in a range of practical contexts; and understand the essence of measuring a quantity; and
- Encouraging students' interest in learning mathematics, promoting creativity and appreciation for solving mathematical problems, and encouraging students' ability to learn.

In primary school (Grades 1–4), the following content strands are defined: Numbers and Number Operations; Quantities; Mathematical Expressions, Equality, and Inequality; Extended Word Problems; Spatial Patterns and Geometric Shapes; and Handling Data. As shown on the following page, Exhibit 1 presents the content students should have learned by the completion of primary school.

In Grades 5 and 6, mathematics is taught as an integrated subject, while in Grade 7 it is split into two subjects: algebra and geometry. According to the National Standards of Comprehensive Basic and Secondary Education, the main objectives of teaching and learning mathematics in the middle school are to do the following:

- Further develop the concept of number and form calculation skills for solving problems;
- Extend mathematical tools acquired in primary school;
- Develop skills of transforming expressions and solving equations and inequalities;
- Develop the understanding of a function as a mathematical model;
- Learn geometric figures on a plane and develop spatial visualization and orientation;
- Form concepts of geometric quantities and the skills required for their measurement and calculation;

Exhibit 1: Mathematics Strands and Content, Grades 1–4

Strand	Content
Numbers and Number Operations	Understand the essence of number as quantity and ordinal counting; and use numbers to quantify and ordinal numbers; be aware of natural numbers and their properties, including zero as a place-holder; and be able to name, read, write, and compare numbers within a million; understand place value; classify and categorize numbers; understand the formation of fractions, including the numerator and denominator of a fraction; name, read, and write fractions; compare fractions with equal denominators; find fractions of numbers; and find a number based on the value of its fraction; understand addition, subtraction, multiplication, and division; know names of the components and results of arithmetic operations; and find the unknown component of an arithmetic operation; know addition and multiplication tables for single-digit numbers; do mental counting within one hundred; use written methods for arithmetic operations within a million; and carry out division with remainder.
Quantities (Length, Weight, Capacity, Duration, Value, and Size)	Estimate the length of objects from everyday life using different measurements; understand and use simple measuring instruments; measure masses with balances; represent mass in different units of measurement; understand that a liter is a standard unit of measuring volume; use clocks and calendars as a means of measuring time; represent different time periods using standard units of time; find the perimeters of polygons; use the formula to calculate perimeters of rectangles; compare and classify an object according to length, mass, and volume; convert one metric unit to another; compare values of similar quantities and perform arithmetic operations with them; use the relationship between units of measurements to solve application problems; and understand that some everyday situations can be described with three interrelated measurements (value, cost, quantity; distance, speed, time).
Mathematical Expressions, Equality, and Inequality	Understand numerical mathematical expressions and their values; define ways of executing arithmetic operations in mathematical expressions, including order of operations; determine the meaning of mathematical expressions; perform arithmetic transformations of numerical expressions; understand mathematical expressions containing variables; understand the dependence of an expression with a variable on the value of that variable; identify, read, write, and distinguish between equalities and inequalities; compare the values of numerical expressions; understand equations with one variable; and solve equations with one variable and check the solution.
Extended Word Problems	Understand word problems; look for patterns in a word problem's structure; analyze word problems and present solutions in diagrams, pictures, and tables; draft solutions of problems, explain the choice of actions, and record the solution expression or equation; find different ways to solve a problem and define the optimal way; check that answers are reasonable; solve simple word problems using arithmetic operations; solve problems with one unknown, problems with proportional values, problems that are the composition of two or four kinds of simple tasks, problems that involve extending a sequence; solve simultaneous equations in two unknowns.
Spatial Patterns and Geometric Shapes	Identify the location of an object on a plane and in space; place and translate objects on the plane; use the correct language and vocabulary to describe spatial transformations; recognize essential features of geometric shapes (points, line segments, planes, angles, polygons, and circles); depict geometric shapes on a grid; build rectangles; label geometric shapes with letters of the Latin alphabet; construct geometric shapes from other shapes; divide geometric figures into pieces; recognize geometric shapes and their elements in space; match the image of geometric shapes with objects in the students' environment.
Handling Data	Be aware of various ways of presenting information; be able to find, analyze, and compare information given in tables and diagrams; enter data into tables; and use data to solve practical problems.

- Learn mathematical language and vocabulary; and
- Understand mathematical concepts and methods as important ways of simulating real life processes and phenomena.

The following strands are defined in teaching and learning mathematics in middle school (Grades 5–9): Numbers; Mathematical Expressions; Equalities and Inequalities; Functions and Numerical Sequences; Elements of Combinatorics; Basics of Probability Theory and Elements of Statistics; Geometric Shapes; and Geometric Quantities. Exhibit 1 presents the content students should have learned by the completion of middle school.

Exhibit 2: Mathematics Strands and Content, Grades 5–9

Strand	Content
Numbers	Understand numerical sets and the relationships between them; calculate with percentages; perform operations on numbers and expressions; and solve word problems.
Mathematical Expressions	Understand standard numerical representations; gain a basic knowledge of exponents (degree, natural and integer index), monomials, polynomials, fractions, and square root; and perform transformation.
Equations and Inequalities	Understand equations and inequalities as mathematical models of real relationships between variables; understand equations and inequalities with one or two unknowns and system of equations of two unknowns; solve linear and quadratic equations and systems of linear equations with two unknowns; understand linear and quadratic inequalities; and solve simple word problems.
Functions and Numerical Sequences	Understand coordinates and coordinate planes and the functional dependencies between variables; understand ways of writing functions and numerical sequences; and understand linear and quadratic functions and quadratic relations; understand arithmetic and geometric progressions.
Elements of Combinatorics	Understand the concept of the set and solve simple combinatorics problems.
Basics of Probability Theory and Elements of Statistics	Be aware of probability theory and statistics as a science; understand random events, the probability of random events, frequency, and average value; understand various ways of collecting and presenting data from different areas of human activity; and use probability to solve simple problems.
Geometry	Know the properties of planar geometric shapes and the equality and similarity of figures; know types of geometric transformations and methods used in geometry; construct shapes using a compass and ruler; understand the length, area and volume of geometric figures and solids; know the formulas for length, area and volume of geometric figures and solids; find the length of a segment, measure angles, area and volume of geometric figures and solids; and find the unknown sides or angles of triangles.

Science Curriculum in Primary and Lower Secondary Grades

In primary school (Grades 1–4), science subjects are taught in a holistic course, People and Environment, which integrates natural science and social science subjects. Natural science subjects account for more than 60 percent of the course. In Grades 5 and 6 of middle school, an integrated science course, Natural History, is taught. In Grade 6, teaching geography begins. In Grade 7, Natural History is no longer taught, and physics, chemistry, and biology are introduced.

In primary school, the objectives of learning in the subject People and Environment are as follows:

- Formation of a system of scientific knowledge at a level accessible by students, including empirical facts, notions, basic concepts (i.e., a level that reflects the laws and regularities of nature and society, and the place of human beings in nature and society);
- Development of students' mental abilities, their emotional sphere, cognitive activity, and independence, including the ability to create, express oneself, and communicate in group activities; and
- Education of a humane, creative, socially active person, able to think ecologically, with concern and respect for other people and oneself.

In middle school, the content of teaching and requirements for student learning are defined by national subject syllabi in the four science subjects (i.e., geography, physics, chemistry, and biology). Exhibits 3–6 present the syllabi requirements and the knowledge, skills, and habits students should have successfully mastered in the four science subjects by the end of middle school.

Exhibit 3: Geography Content, Grades 5–9

Students should be taught to …
Understand the Earth's place in the universe, the sun's influence on nature, and the general laws of the spatial organization of the Earth's geographic envelope.
Know the Earth's form, the characteristics of its movements, and the structure and characteristics of the lithosphere, atmosphere, hydrosphere, and biosphere as components of the Earth's geographic envelope.
Analyze the relationships among the components of the natural world, and give examples of the mutual influence between the natural world and human activity.
Understand the main geographic features of continents and oceans.
Know the main relationships among the components of the natural world on continents and in the oceans, and understand the geography and the natural resource potential of the Ukraine and the students' local environment.
Identify geographic characteristics of continents and oceans, the territory of the Ukraine, and the students' local environment, solve geographic problems, and use geographic knowledge at home and in everyday life.
Have an awareness of the geographic impacts of populations on sustainable development in the Ukraine and in the rest of the world.
Know the history of the settlement of continents in terms of natural conditions and human economic activities, and understand the formation of the nation and the population of the Ukraine, along with current socioeconomic issues in the Ukraine.
Identify geographic characteristics of continents' population and that of Ukraine, and specify, compare, and analyze demographic and socioeconomic data.
Have an awareness of the current geographic picture of the world.
Know about the sources of geographic knowledge exchange and the role of geographic information in human life, be able to use maps, and other sources of geographic information, use acquired knowledge in everyday life, and use tools and instruments to discover geographic processes and phenomena.
Have an awareness of the geographic aspects of the relationship between nature and society in the past and at present.
Know about the main problems of human society and interactions with nature on specific continents and in the territory of the Ukraine.
Be able to give examples of interactions between human society and nature, explain ways of solving geo-ecological regional problems, and follow environmental rules of good conduct.

Exhibit 4: Physics Content, Grades 5–9

Students should be taught to …
Understand the atomic and molecular structure of substances, the discreteness of electric charge, electromagnetic induction, light beams, the characteristics of light propagation in various media, and the activity of radionuclides.
Know properties of solid, liquid, and gaseous states of substances, ways to change the internal energy of a body, radioactivity, gravity of bodies toward the Earth, manifestations of electric and magnetic fields, and the light spectrum.
Be able to solve problems about thermal processes, heat release from fuel combustion, and the construction of images provided by a flat mirror and lenses.
Understand the different types and characteristics of mechanical movement, gravitational and electromagnetic interaction; distribution of mechanical vibrations in an elastic medium; interaction of charged bodies and magnets; the nature of electric current and its mechanical, thermal, chemical and magnetic actions; types and characteristics of heat transmission mechanisms; and features of electric currents.
Be able to solve problems using properties of mechanical movement, the equilibrium condition for a lever, thermal balance equations, the coefficient of efficiency of the mechanism or device, electric circuits, and work and the capacity of an electric current.
Understand the general patterns of physical phenomena in nature, including thermal processes (e.g., the rotation of the Earth causes day and night, energy is transferred from regions of higher energy to adjoining regions of lower energy); know the nature of the law of the conservation of energy, Archimedes' law, Pascal's law, Hooke's law, Ohm's law for a circuit, the Joule-Lenz law, the laws of light reflection and refraction, the law of equilibrium conditions of the lever, and the law of thermal conservation; have an awareness of the elements of meteorology.
Be able to apply physical laws to explain physical phenomena and processes and to solve problems, and have an awareness of the stages of cognitive processes in scientific research.
Know the scientific methods for observation, experimentation, and measurement, and be able to organize an experiment effectively, prepare research plans, measure physical quantities, use measuring devices, construct tables and graphs, analyze and represent research results, and solve physical problems in different ways.
Have awareness of the historical character of the development of physics knowledge and the natural-scientific view of the world.
Know the environmental conditions required to support human life, acceptable standards of environmental pollution, and methods for removing pollutants; and use acquired knowledge to explain the practical applications of physical laws in technical devices and industry equipment, and in other spheres of human activity.

Exhibit 5: Chemistry Content, Grades 5–9

Students should be taught to …
Understand the state of electrons in atoms, stable and radioactive nuclides, and radiation safety.
Know atomic structure, the names and symbols of chemical elements, the periodic law, the structure of the periodic table, and differences in the elemental composition of organic and inorganic substances.
Identify the degree of oxidation of elements in compounds, write formulas for the degree of oxidation, explain the physical nature of the periodic law, and characterize an element according to its atomic structure and its position in the periodic system.
Understand the nature of chemical bonds, the nature of the process of solution, kinds of solutions, and the biological role of inorganic and inorganic compounds; and know about ionic, covalent, and metallic chemical bonds and the names, composition, and properties of major classes of inorganic compounds, the dissociation of substances in aqueous solutions, and the names, composition, chemical structure, and main properties of the most important organic compounds.

Students should be taught to …
Distinguish between the physical and chemical properties of simple and complex inorganic and organic substances, explain the properties of substances based on their composition and structure, write the appropriate equations of chemical reactions, and calculate the mass fraction of a solute.
Understand the characteristics and conditions of chemical reactions, distinguish between physical and chemical phenomena, use the law of the conservation of matter to determine equations of chemical reactions, and carry out calculations for reaction equations.
Understand the role of experimentation in chemistry, know the rules for handling substances safely, be able to perform simple chemical tests, produce solutions, make and describe observations, draw conclusions, solve experimental problems, understand the impact of chemicals on human health and the environment, and know the main ways substances are used.
Be able to use chemicals safely at home and in everyday life.

Exhibit 6: Biology Content, Grades 5–9

Strand	Students should be taught to …
Molecular and Cellular Level	Understand biochemical reactions, the interconnection of cells as the basis for whole organism, the variability of viruses, the formation of resistance to antibiotics in bacteria, and the causes of human diseases; know about the levels of biological systems, the roles of organic and inorganic substances in the metabolism, the most important cell biochemical processes of autotrophic, heterotrophic, aerobic, and anaerobic organisms, and the main provisions of modern cell theory; understand the importance of different life forms in nature (prokaryotes, eukaryotes, and viruses); understand how to prevent viral and bacterial diseases; and solve elementary molecular biology problems.
Organism Level	Understand the mechanisms of maintaining organism homeostasis, and modern biotechnologies and the possible negative impact of their use; know the main properties of organisms, including metabolism, energy transformation, information transfer, laws of heredity, and variability; understand the role of genotype and habitat in forming the phenotype, forms of reproduction, ontogeny and regeneration patterns, organisms' life cycles, achievements of present-day genetics, selection, biotechnology, and genetic and cell engineering; characterize an organism as a complete structural and functional system; solve elementary genetics problems; and evaluate the dangerous influence of environmental factors and one's behavior on one's own life and the health of future generations.
Beyond Organism Levels	Understand the effective use of natural resources and how to increase productivity of artificial ecosystems; understand the population, ecosystem, and biosphere levels in the organization of biological systems, the role of organisms in biosphere nutrient and energy cycles, and processes of self-regulation in ecosystems; know about ecological legislation and its implementation and effect on human activity; use biological knowledge for explaining processes and phenomena; evaluate the impact of humans on natural ecosystems and apply this knowledge in one's own activities; and understand the hypothesis of the origin of life on the Earth.
Organization and Evolution of Organisms	Understand the development of environments in connection with the geological history of Earth; know about the origin of humans; know the principles of biological classification of organisms and how species characteristics are the basis of the modern system for organizing the organic world; know the main phases of the historical development of the organic world and modern views of evolution; explain biological diversity and its impact on human activity and the consequences of the reduction of biodiversity.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Both mathematics and science are mandatory subjects throughout primary and general secondary school. In primary school, a lesson lasts for 35–45 minutes and the academic year consists of 33 weeks. In basic secondary school, a lesson lasts for 45 minutes with the academic year lasting 35 weeks. Exhibit 7 presents the amount of teaching hours in the classroom per week for specific mathematics and science subjects.

Exhibit 7: Teaching Hours per Subject, Grades 1–8

Grade	1	2	3	4	5	6	7	8
Subject								
Mathematics	4	4	4	4	4	4		
Algebra							2	2
Geometry							1.5	2
People and the Environment	1	1	2	2				
Natural History					1	1		
Geography						2	2	1.5
Physics							1	2
Chemistry							1	2
Biology							2	2

In classes with an extensive mathematics or science profile (course of study), the amount of teaching hours in these subjects can be greater. Additional teaching hours for these subjects can be allocated in lieu of the variant content component.

Instructional Materials, Equipment, and Laboratories

Materials for learning mathematics and science include textbooks recommended by the Ministry of Education and Science, Youth and Sport, additional books, activity books or workbooks, and other materials including computer-based resources. Almost all schools are provided with free basic textbooks, the selection of which is centrally conducted for the whole country on a competitive basis. Schools can procure additional teaching materials at their own cost, on the condition that the materials have been recommended or approved by the Ministry.

Use of Technology

As a rule, teachers of mathematics do not approve calculator use as a means of learning during lessons because they consider that such use prevents the development of mental numerical skills. Nevertheless, an increasing number of methods that incorporate calculators and computers into the learning process have appeared recently. For example, many computer-based materials for teaching mathematics and science have been developed to support teaching and learning. However, due to the low availability of computers in mathematics and science classrooms, these materials are not used regularly in classrooms. Indeed, while almost all students have access to computers and Internet at home, mathematics and science classes frequently are not equipped with computers at all, or have one computer available for teacher use only.

The availability and use of equipment and laboratories for teaching chemistry, physics, and biology are reportedly satisfactory, although approximately 35 percent of schools currently are equipped with necessary equipment.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

In primary school, mathematics and the science subject People and Environment are both taught by a general classroom teacher. Students first have specialist teachers for mathematics at Grade 5, geography at Grade 6, and chemistry and biology at Grade 7.

Homework Policies

Traditionally, students are given homework beginning in first grade, and students receive homework assignments in mathematics and science both in primary and middle school. In primary school, homework assignments in mathematics average 20–30 minutes, whereas in middle school they average 35-45 minutes. The expected time for homework in science subjects is somewhat less.

Teachers and Teacher Education

Only individuals who have been specially trained in a teacher education program can teach children.

At present, teacher education in Ukraine is carried out through a network of the following: 24 classical universities; 25 pedagogical universities, universities of Human Arts, or pedagogical universities of Human Arts; two academies; four institutes; 47 pedagogical colleges and high schools; and nine industrial-pedagogical colleges. Currently 479,000 teachers work at secondary schools, of which 89.8 percent have a higher educational background.

The most serious problems facing Ukraine's system for educating teachers are the following:

- Improving the selection procedure for individuals enrolling in teaching degree programs, attaining target enrollments, and implementing teacher education on a "contract basis";
- Optimizing the work of higher education institutions and in-service teacher training establishments, with the purpose of creating necessary requirements for teachers' life-long learning and training; and
- Developing an accountability system aimed at raising the prestige of teachers, and identifying it as a priority in national development policy.

Requirements for Ongoing Professional Development

Every five years, all teachers in Ukraine are required to have retraining courses lasting from two weeks to one month. The education of current teachers is primarily implemented through a system of in-service education and a system of professional training at the workplace. Courses familiarize teachers with innovative methods of teaching their subject, general pedagogical principles, and using information computer technologies in teaching. The special network of in-service institutes, located in each region of Ukraine, is responsible for organizing these courses. The staff of each in-service institute includes one specialist (the "methodologist") for each school subject, whose responsibilities include informing teachers about ministry policy, and supervision of the teachers' use of ministry recommended syllabi and methods of teaching.

Teacher categories officially define a teacher's professional level and influence their salary. A first-year teacher is in the lowest category—"specialist." Over time, primarily on the basis of tenure, a teacher attains the second, first and, finally, in rare circumstances, the top category—"teacher-methodologist." One of the prerequisites of advancing to a higher category is completing an in-service professional development course. In exceptional cases (e.g., for students' victories in a national subject Olympiad), a teacher can receive a special award, such as designation as a top category teacher or the title of Honored Teacher of Ukraine.

Monitoring Student Progress in Mathematics and Science

In the final classes of primary, middle, and high school (i.e., Grades 4, 9 and 11), a mandatory National Final Examination is given to all students. At Grade 4, the examination is held in Ukrainian language and mathematics. At Grade 9, it is held in Ukrainian language, mathematics, geography, and biology, as well as in a foreign language (or another subject chosen by school authorities). In Grade 11, students are assessed in Ukrainian language (mandatory), history of Ukraine (mandatory), mathematics (mandatory, except for students in classes with a philological, social and human arts, artistic-aesthetic, or sports orientation), and in one or two subjects of the invariant content component, according to the student's choice (for students in classes with a philological, social and human arts, artistic-aesthetic, or sports orientation). In secondary schools, profile students are assessed in a subject relevant to their profile. Upon successful passage of the Grade 9 examination, students receive the Certificate of Completion in Basic Secondary Education; successful students at Grade 11 receive the Certificate of General Comprehensive Education. The National Final Examination is both a written and oral examination, and the examination tasks are prepared in advance by the Ministry of Education and Science, Youth and Sport.

Students who complete secondary school and wish to enroll at universities take the Independent External Assessment Testing examinations. These examinations are part of a unified national system of assessment for the majority of invariant content subjects, in particular mathematics and science. Since 2006, the national Independent External Assessment Testing has been carried out by the Ukrainian Center for Monitoring Education Quality, which ensures compliance of the enrollment procedure with the principles of democracy and public transparency. In 2011, about 258,000 individuals registered for Independent External Assessment Testing (in 2010, the number totaled 433,500), and about 202,000 test candidates successfully passed the examination in Ukrainian language and literature (the only mandatory test). In addition, each candidate had the opportunity to be tested in five school subjects (out of twelve offered) in their school language of instruction—Russian, Hungarian, Polish, Romanian, Moldavian, and Crimean Tatar.[4]

Admission to universities takes into account the results of Independent External Assessment Testing and the average grade from the Certificate of General Comprehensive Education.

Aside from the mandatory National Final Examination, some schools have additional examinations at the end of the academic year for students at any grade of middle or high school. In 2001, students of all schools in Grades 5–8 were required to take examinations in some subjects, and mathematics in particular.

Ukrainian schools have a twelve-point school achievement assessment system. Forms of assessment vary from written test papers, students' oral or written answers, practical work, and homework. These types of assessments comprise continuous assessment, and they form the basis for the final grade for each subject, term, and academic year. All grades are entered into class registers. At the end of the term and academic year, each student is given a certificate for their specific grade. Examination content is partially regulated by the subject syllabus and by materials recommended by the Ministry of Education and Science, Youth and Sport, though content also is defined in part by the teacher.

Impact and Use of TIMSS

In order to improve the quality of education in mathematics and science, the relevant documents—Concept and National Target Social Program for Mathematics and Science Education Improvement—were developed and approved. Their goal is to raise mathematics and science education to a considerably new level through standards improvement, content renewal, development of innovative science materials, introduction of innovative methods into teaching practice, and upgrading the postgraduate and in-service mathematics and science teacher education system. Assuming that it is very difficult to teach mathematics and science subjects without necessary resources, the national program envisions the procurement of necessary equipment.

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United Arab Emirates

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Introduction

Overview of the Education System

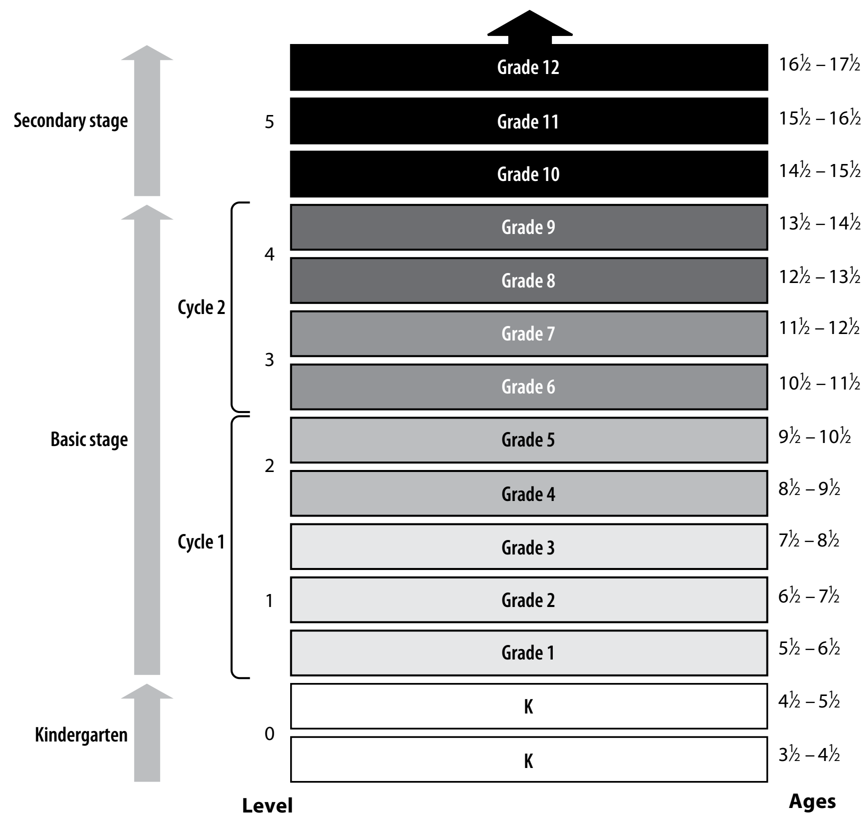
Since the formation of the United Arab Emirates (UAE) in 1971, education has been a top priority in the country. The UAE offers citizens a comprehensive, free public education from Kindergarten through university for both male and female students. In mid-2010, the National Bureau of Statistics estimated the UAE population was 8,264,070, of which 947,997 were UAE citizens.[1] Students attending public schools include UAE citizens, citizens of the Gulf Cooperation Council, in addition to other Arab nationalities. Approximately 36 percent of the UAE population attends public schools (in the Northern Emirates, excluding Dubai and Abu Dhabi).[2] Private education also is offered at different levels and is divided into three types: national private schools, foreign private schools, and foreign community schools. National private schools implement the federal Ministry of Education curriculum and textbooks, while the other private schools have their own curricula and textbooks approved by the ministry.

A key component of government strategy has been the decentralization of educational authority from the ministry to local education bodies in each emirate. Three major bodies are working to improve the education sector: the ministry, which has full jurisdiction over the northern emirates; the Abu Dhabi Education Council; and Dubai's Knowledge and Human Development Authority.[3] Under this structure, the relationship between educational committees, educational councils in each emirate, and educational zones is clearly defined.[4]

In the UAE, Kindergarten is offered for two years and is free and non-compulsory for children ages 3½ to 5½. The Basic Stage is compulsory, comprising two cycles: Cycle 1, covering Grades 1–5 (ages 5½ to 10½, although children at private schools begin Grade 1 at age 5); and Cycle 2, covering Grades 6–9 (ages 10½ to 14½). The Secondary Stage offers education in general schools, religious schools, or through the Institute of Applied Technology (IAT). The former two schools encompass Grades 10–12 (ages 14½ to 17½). Within general schools, students who successfully complete Grade 10 may choose between a science or literature track and receive a Secondary School Leaving Certificate upon completion of Grade 12. IAT encompasses Grades 9–12 (ages 13½ to 17½) and consists of five campuses in the UAE: Abu Dhabi, Al Ain, Dubai, Fujairah, and Ras Al Khaima. Students at IAT may study one of six clusters: Engineering Sciences, Engineering Energy, Applied Mechanical Engineering, Information and Communication Technology (ICT), and Health Sciences and Technology (HST). Upon completion of Grade 12, students receive a Secondary Certificate in Applied Technology, which is fully accredited by the local Ministry of Education.

The stages of the UAE education system are presented in Exhibit 1.

Exhibit 1: The UAE Public Education System[5]



In 2009, the ministry began integrating students from a variety of special needs centers into regular public schools. These students are assessed according to Individual Educational Plans, and are automatically promoted to the next grade at the end of each academic year.[6]

Languages of Instruction

According to the state constitution, the official language of the UAE is Arabic, which also is the language of instruction in public schools. In addition to Arabic, English is taught as a second language, and there are other languages of instruction used in international schools across the UAE.

In the 2007–08 academic year, *Madrasa Al Ghad* (Schools of Tomorrow) was launched in 50 schools as part of a ministry initiative to develop bilingual education in government schools. In *Madrasa Al Ghad*, English language is the medium of instruction used by fourth-grade mathematics and science teachers. However, students and teachers are allowed to use Arabic to provide context and explain vocabulary.[7] Other schools in Dubai and the northern emirates have subsequently adopted the system.

Updating the Mathematics and Science Curriculum in Primary and Secondary Schools

Since 2008, when the Ministry of Education released its strategic plan for educational reform, curriculum revision, teaching standards, and student performance have received attention.[8] The goal of this plan is to ensure that graduates not only are able to compete in a regional knowledge-based economy, but that graduates also are able to be competitive players globally.

To achieve this goal, mathematics experts at the ministry have been working toward replacing the old Basic Education Curriculum with a new standards-based curriculum, adopting the Scott Foresman-Addison Wesley Mathematics textbook series up to Grade 9.[9] Similarly, science experts have been working towards adopting the Harcourt Science textbook series, translated by GEO Projects, for Grades 1–12.[10] These enhanced curricula have been implemented in both the public government and private schools. In *Madrasa Al Ghad*, the same curriculum for science is implemented in English as an instructional language until Grade 4. Mathematics, however, has no specific books; students are taught in English until Grade 4.[11]

The changes in the mathematics and science curricula reflect the expected changes in society's need for the application of these two subjects in the areas of production, technology, and the development of the various sciences.

The development of the mathematics and science curricula is based on a set of four principles and considerations:

- Philosophical—Curricula are developed from the principles of the Islamic faith as the cornerstone of the spiritual and intellectual formation of society, respect for the individual's personality, recognition of mental abilities, and teamwork based on cooperation;
- Social—Curricula are developed to prepare learners to see relationships among science, technology, and society, link the curriculum with the needs of the community, and help learners employ scientific capabilities to meet these needs;
- Psychological—Curricula are developed to link the different parts of the curriculum as well as create learning situations desirable for learners, encourage learning through practice, take into account the mental development and individual differences among learners, motivate learners, and develop their ability to innovate; and
- Knowledge—Curricula are developed to distinguish science and mathematics, which are based on evidence and proof, from other human knowledge.[12]

Mathematics Curriculum in Primary and Lower Secondary Grades

The mathematics curriculum in UAE public schools has been developed around four strands that comprise the knowledge and skills that should be learned by students in Grades 1–12: Numbers and Operations, Algebra and Patterns, Geometry and Measurement, and Data Analysis and Probabilities. An additional five strands comprise the operations related to the thinking skills that the student will use in a variety of situations in mathematics, and other subject areas, and apply to activities in their daily lives: Problem Solving, Reasoning, Proof, Communication, and Representation.[13]

By the end of Grade 4, public school students should have been taught the following topics: [14]

- Numbers and Operations—Place value up to millions; comparisons and ordering of whole numbers, fractions and decimals; adding and subtracting whole numbers; multiplying two-digit whole numbers; dividing three-digit numbers by two-digit numbers; approximating whole numbers to the nearest ten, hundred, or thousand; approximating decimals to the nearest tenth or hundredth; and factoring whole numbers into prime factors.

- Algebra and Patterns—Finding the missing terms in a sequence or series; describing and finding rules for patterns from tables; and solving simple equations.
- Geometry and Measurement—Identifying and comparing angles (acute, right, obtuse, and straight); identifying and classifying triangles by angles and by sides; identifying and classifying quadrilaterals (squares, rectangles, parallelograms, trapezoids, and rhombuses); identifying congruent figures; identifying time periods using a calendar; recognizing transformations (translation, line of symmetry and reflection, and rotation) of simple shapes; calculating area and perimeter of the square and the rectangle; and describing solids (cube, rectangular prism, sphere, cone, pyramid, and cylinder).
- Data Analysis and Probabilities—Reading and interpreting data from tables, bar graphs, pictograms, histograms, and line plots; finding range, mean, mode, and median for a set of data; judging the probability of an outcome as certain, more likely, equally likely, less likely, or impossible; and locating and reading points in the first quadrant of the Cartesian plane.

By the end of Grade 8, public school students should have been taught the following topics: [15]

- Numbers and Operations—Whole numbers, integers, fractions, decimals, and mixed numbers; properties of numbers; estimation strategies for numbers; comparison and order of numbers; the four arithmetic operations and the order of operations; ratios and proportions; unit rates; percent and applications of percent; and approximation of square roots.
- Algebra and Patterns—Identifying patterns, graphs, and number sequences; solving pattern problems; understanding the rules of function; interpreting graphs; transforming formulas; evaluating and writing algebraic expressions; solving two-step linear equations by using the four arithmetic operations; and graphing, writing, and solving inequalities.
- Geometry and Measurement—Classifying angles and parallel lines; lines and planes; similar figures; maps and scale drawing; the Pythagorean Theorem; viewing solids and surfaces; area and perimeter of two-dimensional shapes (regular and non-regular); surface area and volumes of prisms, pyramids, cylinders, and spheres; graphing linear equations; solving simultaneous linear equations by graphing; tables and graphs;

the slope of a line; graphing nonlinear relationships; transformations (translation, line of symmetry and reflection, and rotational); and tessellations.

- Data Analysis and Probabilities—Using spreadsheets and data displays; using stem and leaf plots; understanding random samples; using graphs (e.g., pie graphs) to analyze data (range, mean, mode, and median); estimating population size; using data to persuade; exploring scatter plots; experimental and theoretical probability; sample space; and understanding compound events, counting principles, permutations, and combinations.

Science Curriculum in Primary and Lower Secondary Grades

Upon the completion of Grade 4, students in public schools are expected to develop the following competencies: [16]

- Understand and apply skills used in scientific inquiry;
- Know types of energy sources and their uses;
- Understand the properties and behaviors of common materials under a range of conditions;
- Develop a strong sense of self and relationships, including how to be an active learner and care for plants and animals; and
- Use experiences, information, and communication to develop an understanding of the environment and of what humans need to live on Earth.

Upon completion of Grade 8, public school students are expected to develop the following competencies: [17]

- Understand that the physical and chemical properties of matter have applications in all disciplines of science, from the chemical reactions that keep us alive to those taking place within stars, and recognize the composition and structure of elements, molecules, compounds, and mixtures and their use in the 21st century;
- Know and understand chemistry in order to be able to monitor, understand, and improve the quality of the environment, and to develop new technologies that will improve quality of life;

- Understand how different forms and uses of energy provide a basis for understanding the fundamental physical processes occurring within the universe, from the large-scale movement of planets to the emission of nuclei in radioactive materials;
- Understand life in all its forms, from microscopic to macroscopic, and the processes that occur within and between living things, including the interactions between different species, human impact on the environment, management of the environment, conservation of endangered species, and the study of microbes that cause disease;
- Examine the nature of geologic processes and physical features on Earth, the features and processes occurring on other planets of the solar system and beyond, and the impact of natural disasters, such as earthquakes and volcanic eruptions that shape the world we live in; and
- Identify the relationships between celestial bodies and how they influence each other.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Materials, Equipment, and Laboratories

The Ministry of Education in the UAE provides instructional materials free of charge for all students in public schools. Each student in the fourth grade receives the Scott Foresman-Addison Wesley Mathematics textbooks series. Mathematics books provided to students and teachers in the public schools are listed in Exhibit 2.[18, 19]

Most fourth and fifth grade mathematics teachers use presentation equipment and tools (cards and overhead projectors) and other "Instructional Packages" containing manipulatives, such as models, shapes, fractional parts, geometrical shapes, currencies and coins, dice, and models of units of measurement, weights, and volumes.[20]

The science curriculum in the UAE schools is based on the Harcourt Science textbook series. Science books provided in public schools are listed in Exhibit 2.[21, 22]

Exhibit 2: Mathematics and Science Text Resources for Students and Teachers in the Public Schools

	Mathematics		Science	
Grade	**Fourth**	**Eighth**	**Fourth**	**Eighth**
Students	Student Textbook		Student Textbook	
	Student Practice Book		Student Practice Book	
	Math Enrichment Workbook	The Guide to Solving Problems		
Teachers	Teacher Guide Book		Teacher Guide Book	
	Teacher Practice Book with answers		Teacher Practice Book	
	Assessment Guide		Assessment Guide	
	Math Enrichment Workbook (with answer key)	The Guide to Solving Problems (with answer key)	Learning Package	

The ministry exerts all possible efforts to provide all public schools with the facilities needed for the teaching and learning process. All schools are equipped with laboratories, learning resources rooms, and other rooms for scientific activity equipped with a variety of supporting materials that play an important role in developing students' creative skills.[23]

Use of Technology

Students may use calculators in Grades 4–8 to verify their solutions and to facilitate the process of solving mathematical problems. However, students may not use calculators during the end-of-year exams in Grades 1–8.

Students use computers in Grade 6 on some projects related to the subject areas studied. Mathematics and science teachers in public schools use computers in their classrooms in Grades 4–8 for demonstration and enrichment purposes, to introduce facts and information to the students, and to enable students to do virtual experiments. Moreover, the publishers Harcourt and Scott Foresman-Addison Wesley provide software licenses for teachers to access additional supporting materials from educational sites corresponding to their textbooks.[24]

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Students in Grades 1–3 in all public schools have three different teachers: one for Arabic language and Islamic education, one for mathematics and science, and one for English language. Beginning in Grade 4, students have specialist teachers for mathematics and science. In Grades 10–12, students have specialist teachers for each science area: physics, chemistry, biology, and geology.[25]

Homework Policies

Homework is one of the means of reinforcing and expanding the skills that students gain during classroom sessions. Homework is usually based on the content of each subject, and sometimes teachers assign a variety of out-of-school activities, such as science research projects.[26]

Teachers and Teacher Education

Teacher Education Specific to Mathematics and Science

Before teaching, teachers must acquire knowledge and specialized skills, as well as professional, cultural, and community skills that are learned in schools of education and human sciences in colleges and universities. Teachers in public schools must complete, on average, four years of university-level study, either at education colleges or specialist colleges. Graduates of specialist colleges also receive additional pedagogical training, arranged exclusively by the ministry, before they start teaching.

The qualifications and conditions for teaching in public schools differ depending on whether the candidate is a UAE national or an expatriate; particularly, the number of years of experience required and compensation are different. Non-national candidates should not be older than 40 in the academic year applied for and must have at least three years of teaching experience, while national candidates' age criterion is subject to the Civil Service Bureau rules and regulations. Further, national candidates are not restricted by a minimum GPA average, while non-nationals must obtain at least an average of a "C," except in the case of those who hold education diplomas and higher degrees. Nationals retain priority in job placement. Priority also is given for holders of the International Computer Driving License Certificate (ICDL) and a certificate in the Test of English as a Foreign Language or the International English Language Testing System.

Mathematics and science teachers must have the equivalent of a bachelor's degree in mathematics or science, and preferably an educational diploma. In addition, to be qualified as mathematics or science teachers for Grades 4–12, candidates should hold the ICDL. New teachers also are required to pass a written examination and a professional interview.[27]

Requirements for Ongoing Professional Development

Professional development is the responsibility of both individual teachers and the Ministry of Education.[28] Once employed, teachers must continue to develop their knowledge and professional and cultural skills. Professional development programs for new and experienced teachers are organized by departments within the ministry or educational districts under the guidance of the supervision departments within these districts. These programs are designed to meet teacher needs within each district and are developed based on classroom visits and questionnaires from teachers in addition to teachers' cumulative records.

Most professional development programs concentrate on developing competency in mathematics and science as well as pedagogy for those teachers who have not graduated from schools of education. The major topics addressed in professional development programs for mathematics and science teachers include the following:

- Features of the educational system in the UAE and regulations governing the performance of teachers;
- Assessment of student learning;
- Modern teaching methods;
- Effective classroom learning;
- The learning environment; and
- Integrating special needs students into the education process.[29]

Teacher performance is monitored through classroom visits by the mathematics and science supervisors in their schools. Supervisors recommend suitable training programs and workshops for teachers as needed. Also, mathematics and science supervisors encourage new teachers to participate in exchange visits and programs focused on curriculum and assessment regulations.[30]

Monitoring Student Progress in Mathematics and Science

Continuous assessment occurs in all grades in public schools in the UAE. Different evaluation tools are used, depending on the grade and the subject. Students in Grades 1–5 are assessed with written tests prepared by their teachers at the end of each textbook unit in each subject. Other evaluation tools include the following: classroom activities, such as oral presentations, written activities, and practical exercises; and non-classroom activities, such as research projects and portfolio construction. According to the Ministry of Education examination system, students are promoted to the next grade automatically. However, if a student does not achieve 50 percent on the total examination score, he or she will be enrolled in a remedial program at the end of the school year. If a student still fails, he or she will enroll in another remedial program at the beginning of the following year to support his or her learning in the next grade.

Students in Grades 6–9 are assessed using the same system in place for students in Grades 1–5 in both mathematics and science. These students also take short written tests. Students need a total score of 50 percent in each subject to pass and be promoted to the next grade. However, if a student fails an examination in any given subject (up to a maximum of three subjects), he or she is allowed to retake the exam at the end of the academic year and before the summer holiday. If the student fails the exam again, he or she must repeat the grade.

At the end of each semester, students in Grades 1–9 in public schools receive a report card, which includes the scores obtained in each subject and level of evaluation, as well as any promotional comments or observations related to remedial programs from teachers of all subjects. Teachers record the standards of student performance and areas of improvement, which are presented to students' guardians periodically with teacher recommendations, notes, and evaluations.[31]

Impact and Use of TIMSS

This is the first time the UAE has participated in TIMSS. Administrating TIMSS 2011 across the UAE will provide decision-makers with international comparisons to measure student knowledge and skills in both mathematics and science. Also, participation will help to identify the contextual factors that affect student performance and achievements in these two subjects.

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The United States

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Introduction

Overview of the Education System

Public education is decentralized in the United States; each state governs its own school system. States oversee all levels of education and direct (or delegate to local authorities) all aspects, including political, administrative, and fiscal aspects that would generally be directed by a ministry of education in a centralized system. The degree of a state's control, in comparison to that of local authorities, depends on state laws and regulations; but, in every state, education is the largest budget item.[1] State education departments distribute federal and state funding, establish policy for graduation requirements and teacher certification requirements, provide curriculum guidance, conduct student assessments, and are responsible for ensuring that efficient and effective school opportunities are made available to every eligible child in the state. In the 2010–11 school year, an estimated $1.1 trillion was spent nationwide to fund all levels of education, with the substantial majority of that funding for elementary and secondary schools coming from state and local public funding; only around 10 percent of that funding came from federal sources.[a, 2]

States delegate the operation of elementary and secondary schools to local governments which, in turn, have traditionally assigned the task of running schools to elected or appointed school boards. Local school boards raise funds, establish policy and operating regulations, and hire superintendents to manage and operate the district. The local district is responsible for curriculum decisions, standards implementation, facilities construction and maintenance, and operation of school programs. In the 2008–09 school year, there were about 13,800 school districts in the United States.[3] In 2007, approximately 86 percent of U.S. elementary and secondary school students attended the public schools in these districts, 11 percent attended private schools, and 3 percent were homeschooled.[4]

a Federal funding for public education includes funds not only from the U.S. Department of Education but also from other Federal agencies, such as the U.S. Department of Health and Human Services' Head Start program and the U.S. Department of Agriculture's School Lunch program.

While state and local governments have the primary responsibility for education in the United States, the federal government also plays a role in state education systems. Since 1917, the federal government has offered states funding to support various programs, including vocational education as well as mathematics, science, and foreign language programs. Since the 1960s, the federal government also has promoted equal educational opportunities through the Elementary and Secondary Education Act (ESEA). ESEA makes equal educational requirements a condition for federal funding and provides aid (known as Title I funding) to high-poverty schools to improve the learning of educationally disadvantaged children. In 1980, the federal Office of Education became the U.S. Department of Education, a Cabinet-level department with the additional responsibilities of promoting improvements in the quality and usefulness of education through federally supported research, evaluation, and sharing of information.[5]

In 2002, ESEA was reauthorized as the No Child Left Behind Act (NCLB), which made federal funding conditional on educational results.[6] Specifically, NCLB requires states to ensure that all students are proficient in reading, mathematics, and science by the 2013–14 school year based on state academic content standards. NCLB measures school performance by whether certain percentages of students and student subgroups (e.g., economically disadvantaged students and students with limited English proficiency) reach state proficiency standards on the state assessment each year. If a school's percentages exceed its preceding year's percentages by certain amounts, the school is considered to have made adequate yearly progress (AYP).

In addition to the publicly funded and operated school systems, major religious denominations and other private groups operate schools in the United States. These schools charge a tuition fee and operate under their own rules and regulations. In 2007, 11 percent of U.S. students enrolled in Kindergarten through twelfth grade attended private schools, of which about 78 percent had religious affiliations.[7]

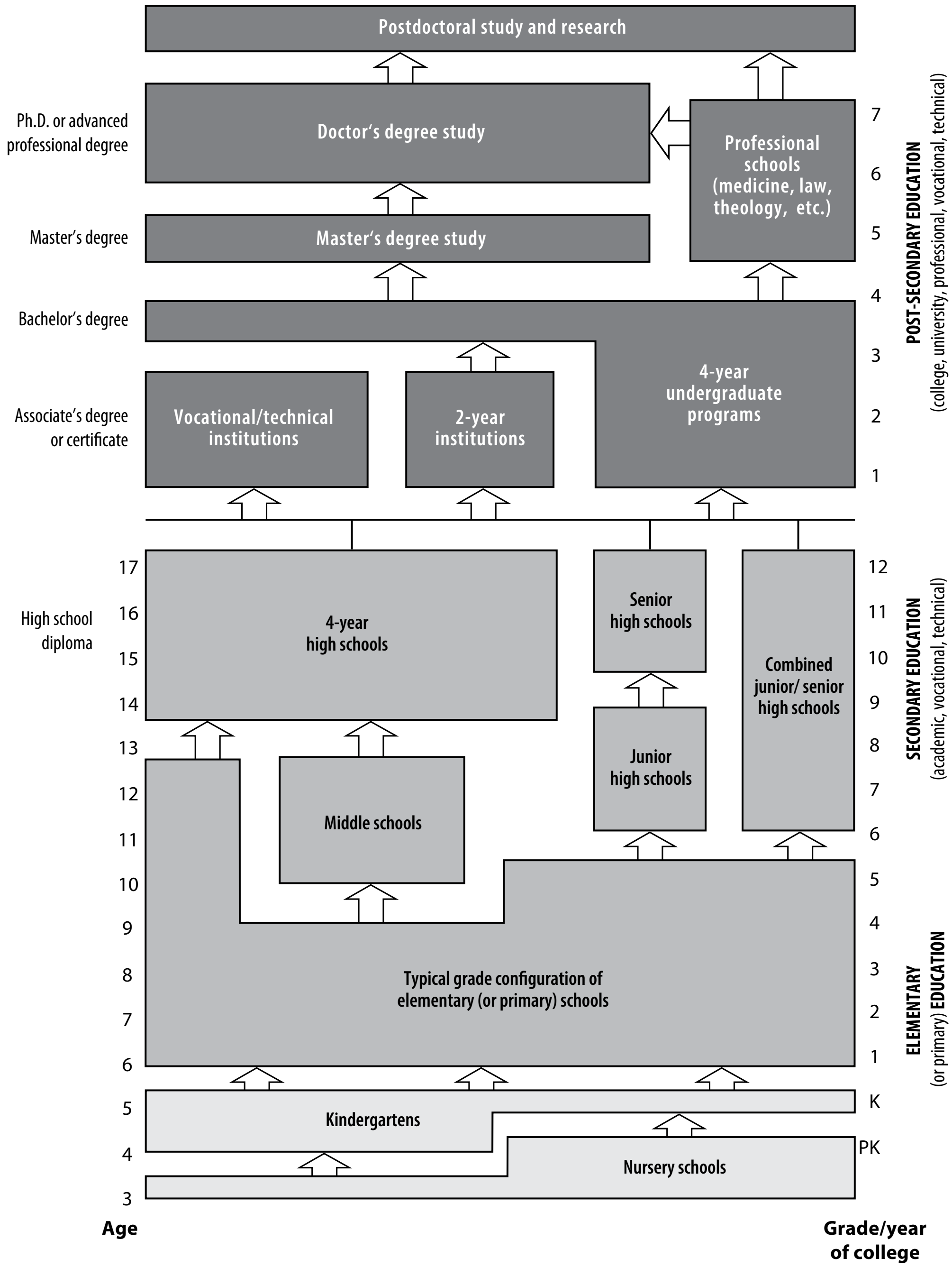
In recent years, a growing number of parents have elected to homeschool their children. Homeschooled children may be taught by one or both parents, by tutors who come into the home, or through virtual school programs available on the Internet. In 2007, approximately 2 million school-aged children (3% of all school-aged children) were reported by their parents to be homeschooled.[8]

The state in which the family resides is responsible for any oversight of homeschooling.[9]

In the United States, public education refers to the system by which federal, state, and local governments provide the funding and oversight for free public schools for all children from Kindergarten (ISCED Level 0) through Grade 12 (when most students are age 18). Publicly funded education ends when a student graduates from high school or finishes Grade 12. (The age at which students are permitted to leave school before graduation varies among the states.)

School districts organize grades into elementary schools (Kindergarten and Grades 1–4 or 1–5, sometimes called primary schools), middle schools (Grades 5–8, 6–8, or 7–8, sometimes called intermediate or junior high schools), and high schools (typically Grades 9–12 or 10–12, sometimes called secondary schools). At age 5, a child typically enters Kindergarten and will generally be promoted to first grade the following year. In the lower grades of elementary school, students usually have one teacher for all core academic subjects, including mathematics and science, and remain with the same peer group for the full year. In middle schools, students usually move to different classrooms throughout the day, have a different teacher for each subject, and may or may not stay with the same peer group for different classes. In many U.S. middle schools, students are offered some choice in selecting elective courses outside the core academic subjects. Eighth grade, the grade at which TIMSS is administered in the United States, is considered lower secondary under the International Standard Classification of Education (ISCED). In high school, students have more choices in their academic program. Accelerated academic pathways and career and technical education options are often offered, and more electives are available to accommodate students' interests. Academic grades are recorded in student transcripts, which are used to document completion of graduation requirements and for competitive admission to higher education. After graduation from high school, students may continue their education by enrolling in public or private universities or colleges, community colleges, or vocational or technical schools (see Exhibit 1).

Exhibit 1: The Structure of Education in the United States[10]



As noted above, the reauthorization of ESEA as NCLB is the major federal legislation affecting education. It requires states to ensure that all students be proficient in reading, mathematics, and science by the 2013–14 school year based on state academic content standards.

The federal government also has established the Race to the Top Fund under the American Recovery and Reinvestment Act (ARRA) of 2009. The Race to the Top Fund is a competitive grant program meant to support state education reforms that improve students' college and career preparation, build data systems to aid teachers and principals in measuring student growth, recruit and develop effective teachers and principals, and turn around low-achieving schools.[11] The $4.35 billion Race to the Top grant program has been directed to ensure a competitive preference to states that commit to improving science, technology, engineering, and mathematics (STEM) education, among other goals.[12]

There is no national curriculum in the United States. State education agencies and local school districts are responsible for subject area curriculum frameworks. States are responsible for developing curriculum frameworks in core subject areas and implementing accountability systems tied to curriculum standards. Local school districts and, sometimes, individual schools decide what curricula are actually taught. For all states and districts, the curricula for mathematics and science prescribe a series of topics, content standards, and indicators of student achievement. In developing and revising curriculum frameworks, state departments of education and local districts typically rely on committees of subject specialists to collaboratively review and make decisions about the curriculum.

However, in 2010 and 2011, 43 states and the District of Columbia adopted the Common Core Standards Initiative's mathematics curriculum (described in the "Mathematics Curriculum in Primary and Lower Secondary Grades" section of this chapter).[13] Started in 2009, the Common Core State Standards Initiative is a state-led effort sponsored by the National Governors Association (NGA) and the Council of Chief State School Officers to bring diverse state curricula into alignment with each other by establishing a shared set of clear educational standards for English language arts and mathematics that states can voluntarily adopt.

Under the NCLB Act of 2002, all states are required to administer annual assessments in mathematics and reading for Grades 3–8, and at least once in Grades 10–12. Beginning with the end of the 2007–08 school year, testing also is required in science at least once during Grades 3–5, 6–9, and 10–11. Results from the mathematics assessments are used to determine whether schools are making adequate yearly progress toward the goal of having all students performing at state-set, grade-level proficiency levels by the 2013–14 school year.[14] Additionally, the National Assessment of Educational Progress (NAEP), commonly referred to as "The Nation's Report Card," assesses states' progress in several subject areas, including mathematics and science, in Grades 4, 8, and 12. National leaders discuss the importance of improving STEM programs at state and local levels and the need to fund STEM programs for sustained success and student college and career readiness.

In November 2009, the Educate to Innovate campaign was launched with public-private investments totaling $260 million for the purpose of motivating students to excel in STEM education. Educate to Innovate focuses on three priorities: increasing critical thinking skills in STEM literacy, improving the quality of teaching of STEM subjects for the purpose of improving how American students compare with students from other nations, and offering more opportunity to women and minorities in STEM-related education and careers. Through the public-private partnerships, the campaign intends to reach millions of students by using media, interactive games, and hands-on learning to motivate their active participation in STEM-related education and fields.[15]

As a response to the Educate to Innovate campaign, Change the Equation, a new non-profit organization, was established in 2010 with a membership of over 100 nationally recognized CEOs (Chief Executive Officers) and funding of $5 million in its first year.[16] The aims of Change the Equation are to improve the quality of teaching, inspire learners, and commit society as a whole to improving literacy in STEM through its network of CEOs and other STEM stakeholders.[17] Also in 2010, five more public-private partnerships were added to the Educate to Innovate campaign portfolio, increasing funding to improve STEM teaching quality by an additional $250 million.[18]

In 2010, Congress also passed the America Competes Act, which aims to strengthen mathematics, science, and foreign language education in order to improve the next generation's readiness for a rapidly changing workforce in which technological innovation and global competition are often connected. The America Competes Act of 2010 authorizes budgets for three key agencies focused on science and technology advancement: the Department of Energy's Office of Science, the laboratories of the National Institute of Standards and Technology, and the National Science Foundation. Further, the America Competes Act of 2010 specifically supports innovative research for technologies that reduce reliance on foreign energy and stimulate a green economy; in addition, it gives federal departments and agencies authority to conduct competitions to reward those with skill and expertise in solving national problems.[19]

Additionally, there are several smaller federal programs in place to support and supplement mathematics and science education. The Mathematics and Science Partnerships program provides subject-specific professional development to teachers.[20] The Upward Bound Math-Science program funds independent programs that encourage students to recognize and develop their potential to excel in mathematics and science, and to pursue postsecondary degrees in these subjects.[21]

Languages of Instruction

There is no official language in the United States, but English is the primary language in the country. In 2007, 80 percent of the population over the age of five spoke only English at home.[22] English is the language of instruction for academic subjects, including mathematics and science, at all academic levels. The second most commonly spoken language at home is Spanish, spoken by 12 percent of the population.[23]

The population of school-age children that speaks a language other than English at home has increased over time. Between 1980 and 2009, the number of school-age children (ages 5–17) who spoke a language other than English at home increased from 5 to 11 million or from 10 to 21 percent of all children in this age group. The number of school-age children who spoke English with difficulty also increased over the same period, albeit not in a linear fashion. This population increased from 2 million (or 4% of all school-age children) in 1980 to 4 million (or 7% of all school-age children) in 2000, before decreasing to 3 million (or 5% of all school-age children) in 2009.[24]

Mathematics Curriculum in Primary and Lower Secondary Grades

Curriculum frameworks vary in individual states. Emphasis is placed on mastering basic skills or procedures, understanding concepts or principles, and applying mathematics in real-life contexts. The curriculum is communicated through publications, online resources, instructional guides, and recommended instructional activities.

Exhibit 2 shows the mathematics topics and skills generally taught by the end of eighth grade. Additional topics not included in the exhibit may appear in the curriculum in some states. While the exhibit generally represents the material in states' curricula, individual curriculum frameworks always include detailed, grade-level instructional benchmarks, approaches to learning, and instructional resource material.

Exhibit 2: Mathematics Curriculum Topics Taught Through Eighth Grade

Area of Mathematics	Topics
Numbers	Whole numbers, place value, factorization, and the four operations
	Computation, estimations, and approximations involving whole numbers
	Fractions, equivalent fractions, and ordering of fractions
	Decimals, place value, ordering, and converting to common fractions
	Representing decimals and fractions using words, numbers, models, and number lines
	Computation with fractions
	Computation with decimals
	Representing, comparing, ordering, and computing with integers
	Ratios: equivalence, and division of a quantity in a given ratio
	Conversion among percent, decimals, and fractions
Algebra	Numeric, algebraic, and geometric patterns
	Sums, products, and powers of expressions containing variables
	Evaluating expressions for a given numeric value
	Simplifying or comparing algebraic expressions
	Modeling situations using expressions
	Simple linear equations and simultaneous (two-variable) equations
	Equivalent representations of functions as ordered pairs, tables, graphs, words, and equations
Geometry	Angles: acute, right, straight, obtuse, and reflex
	Relationships for angles at a point, on a line, vertically opposite angles, those associated with a transversal cutting parallel lines, and perpendicularity
	Properties of geometric shapes: triangles, quadrilaterals, and other common polygons
	Constructing or drawing triangles and rectangles of given dimensions
	Congruent figures (quadrilaterals, triangles) and their corresponding measures
	Similar triangles and their properties
	Relationships between two- and three-dimensional shapes
	Pythagorean theorem to find length of a side of a right triangle
	Measurement, drawing, and estimation of the size of angles, length of lines, areas, volumes
	Measures of irregular or compound areas
	Cartesian plane: ordered pairs, equations, intercepts, intersections, gradient
	Line and rotational symmetry for two-dimensional shapes
	Translation, rotation, reflection.
Data and Chance	Reading data from tables, pictographs, bar graphs, pie charts, and line graphs
	Organizing and displaying data using tables, pictographs, bar graphs, pie charts, and line graphs
	Characteristics of data sets including mean, median, range, and shape of distribution
	Interpreting data sets (drawing conclusions, making predictions, and estimating values between and beyond given data points)
	Data display that could lead to misinterpretation
	Using data from experiments to predict chances of future outcomes
	Using the chances of a particular outcome to solve problems

The Common Core Standards for Mathematical Practice describe knowledge and skills that mathematics educators at all levels should seek to develop in their students. In Grade 4, instructional time should focus on three critical areas:

- Developing fluency with multi-digit multiplication and division;
- Developing an understanding of the equivalence and multiplication of fractions; and
- Understanding that geometric figures can be analyzed and classified based on their properties.[25]

In Grade 8, instructional time should focus on three critical areas:

- Formulating and reasoning about expressions and equations, including solving linear equations;
- Grasping the concept of a function and using functions to describe quantitative relationships; and
- Analyzing two- and three-dimensional space and figures using distance, angle measure, similarity, and congruence.[26]

Science Curriculum in Primary and Lower Secondary Grades

The curriculum frameworks of individual states vary. However, in general, emphasis is placed on knowing basic science facts and principles; observing natural phenomena and describing what is seen; and designing, planning, and conducting experiments and investigations (more in eighth than in fourth grade). The curriculum is communicated through publications, online resources, instructional guides, and recommended instructional activities. The Common Core Standards Initiative, which has so far focused on reading and mathematics, has yet to develop curriculum standards for science instruction in the United States.

Exhibit 3 shows the science topics and skills generally taught by the completion of eighth grade. Additional topics not included in the table may appear in some states' curricula. While Exhibit 3 generally represents the material in states' curricula, specific curriculum frameworks include detailed grade-level instructional benchmarks, approaches to learning, and instructional resource material.

Exhibit 3: Science Curriculum Topics Taught Through Eighth Grade

Area of Science	Topics
Chemistry	Classification and composition of matter (physical and chemical properties, pure substances and mixtures, and separation techniques)
	Particulate structure of matter (molecules, atoms, protons, neutrons, and electrons)
	Solutions (solvents, solutes, and the effect of temperature on solubility)
	Properties and uses of water (composition, melting and boiling points, and changes in density and volume)
	Properties and uses of acids and bases
	Chemical change (transformation of reactants, evidence of chemical change, and conservation of matter)
	Common oxidation reactions (combustion, rusting), the need for oxygen, and the relative tendencies of familiar substances to undergo these reactions
Life Science (Biology)	Classification of organisms
	Structure and function of cells
	Systems in living things
	Reproduction and heredity
	Evolution and biodiversity
	Living things and their environment
	Energy and living things
	Changes in ecosystems over time
Physics	Physical states and changes in matter
	Processes of melting, freezing, evaporation, and condensation
	Energy forms, transformations, heat and temperature, and heat transfer
	Temperature changes related to volume and pressure, and changes in movement or speed of particles
	Basic properties and behavior of light (reflection, refraction, light, color, and simple ray diagrams)
	Properties of sound
	Electric currents
	Properties of permanent magnets and electromagnets
	Forces and motion, use of distance and time graphs
	Effects of density and pressure
Earth Science	Earth's structure and physical features
	The physical state, movement, composition, and relative distribution of water on Earth
	Earth's atmosphere and the relative abundance of its main components
	Earth's water cycle
	Processes in the rock cycle and the formation of igneous, metamorphic, and sedimentary rock
	Weather data and maps and changes in weather patterns
	Geological processes occurring over millions of years
	Formation of fossils and fossil fuels

Area of Science	Topics
Earth Science	Environmental concerns
	Earth's resources
	Relationship of land management to human use
	Supply and demand of fresh water resources
	Explanation of phenomena on Earth based on movement of bodies in the solar system
	Physical features of the Earth, and comparisons with the moon and other planets

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Materials, Equipment, and Laboratories

There are no national policies governing the use of instructional materials, equipment, and laboratories, although state and national organizations and the federal government provide some guidance. The Federal Resources for Educational Excellence publishes an index of teaching and learning resources available from federal agencies.[27] Teaching resources are made available through private organizations' and government agencies' websites on all topics in the curriculum for mathematics and science. The National Science Foundation, for example, has a publicly accessible National Science Digital Library to provide exemplary resources for science, technology, engineering, and mathematics.[28]

States use one of two methods to select the textbooks used in their schools. The majority of states allow school districts or schools to choose the textbooks they will use. However, many states (21 in 2008) either select or recommend what textbooks can be used by all districts.[29] Because some of these states, known as textbook adoption states, have large student populations (e.g., California and Texas), they can greatly influence the market of published textbooks. In addition, because textbooks are produced by independent publishing houses with the intention of selling their books to as many districts as possible, many textbooks used in U.S. schools have more material and topics of study than a teacher will actually cover in one year.

Use of Technology

The use of technology in U.S. public schools has been growing in recent years. The ratio of public school students to instructional computers with internet access has decreased from 7:1 in 2000 to 3:1 in 2008.[30] In 2009, 40 percent of teachers reported that they or their students used computers in the classroom "often," while 29 percent reported using them "sometimes."[31] Additionally, use of information technology has had an impact on instructional planning. The percentage of public school teachers using the Internet for instructional or administrative purposes was 94 percent in 2009.[32]

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Under the NCLB Act of 2002, all middle and upper secondary teachers (Grades 6–12) are required to be specialists within their fields. However, some states allow teachers with an elementary-level certification to teach at the middle school level. In this case, they may not have specialized knowledge in a discipline even if they are teaching the subject. Teachers are identified as specialists either by passing a state academic subject test or by successfully completing an undergraduate major, holding a graduate degree, completing coursework equivalent to an undergraduate major, or holding advanced certification or credentialing.

Homework Policies

Homework policies and practices vary across states and local school districts. The amount of time students at a given grade level are expected to spend on mathematics and science homework in a given week varies according to the policies established by local school districts, schools, and sometimes teachers. In general, educational activities completed at home are viewed as opportunities for practicing skills and reinforcing understanding of material learned in the classroom. Student assessments are rarely completed outside the classroom, with the exception of long-term, multi-step projects.

Teachers and Teacher Education

Teacher Education Specific to Mathematics and Science

The traditional educational pathway for a public school teacher includes a degree from a four-year college or university and completion of a teacher-education program, including a practicum of supervised teaching experience. In current teacher education programs, early childhood educators (pre-Kindergarten–Grade 3) and elementary school teachers (Grades 1–5) usually earn a bachelor's degree in education, while secondary school teachers may earn a bachelor's degree in their specific subject area, a double major in their subject and education, or a master's degree in education in addition to the bachelor's in their subject area.

All public school teachers must be licensed. Each state's department of education is responsible for granting licenses. Most colleges and universities, public and private, have a department or school of education that offers teacher-education programs aligned with their state's licensure requirements. In recent years, there has been a proliferation of alternate routes to certification and licensure, primarily in response to a need to find teachers in hard-to-staff schools or in subject areas such as mathematics, science, and special education. Some classifications of licenses include provisional, standard, professional, and permanent. Each license may have a different period of validity. Most states require some testing, such as tests of basic skills (reading, writing, and mathematics), tests to show mastery of the subject to be taught, or tests in general pedagogy. Many states now also offer alternative programs for licensure by allowing teacher applicants to begin teaching while completing a one- or two-year teacher-education program. Teacher applicants must have received a bachelor's degree and demonstrate subject knowledge in order to participate in such alternative programs. Requirements for licensure for public school teachers of mathematics and science are the same as those that currently apply to all public school teachers in the United States and are mandated by all state education agencies. Some states require teachers to obtain a master's degree as part of license maintenance.

Under the NCLB Act of 2002, all teachers must be highly qualified, as defined by law. This means that all teachers must obtain a teaching license from their state, have at least a bachelor's degree, and demonstrate expertise in their field. To demonstrate subject knowledge, new elementary school teachers must pass tests of both teaching skills and the academic areas of basic elementary school curricula, including language arts, reading, and mathematics. New middle and high school teachers must demonstrate expertise in the subject(s) they teach by either passing a specified academic subject test or the successful completion of an undergraduate major, a graduate degree, coursework equivalent to an undergraduate major, or an advanced certification or credentialing.[33]

In the 2007–08 school year, 99 percent of the nation's 3 million plus elementary and secondary public school teachers had at least a bachelor's degree, and 52 percent also had a master's degree or other degree or certificate beyond a bachelor's degree.[34]

Requirements for Ongoing Professional Development

Most states require continuing professional development and education for renewal of teacher licenses. Often, school districts provide opportunities for teachers to continue their education through professional development activities organized by the school district. Many districts have professional development coordinators or specialists whose primary focus is to assist teachers with professional development and attaining credits toward re-licensure.

There are no national policies that prescribe the content and methods of professional development programs. Some approaches to professional development implemented by states are the following:

- Short-term workshops;
- Summer institutes for teachers to receive specialized training and equipment;
- Master teacher programs that provide specialized training and financial incentives to participating teachers;
- Professional development opportunities for teachers specifically in high-needs districts that may include a combination of the above; and
- Special training and support for teachers of advanced secondary school courses.

Most teachers' professional development activities are supported or organized by their schools or school district.[35] In 2007–08, 92 percent of elementary school teachers and 82 percent of secondary school teachers participated in professional development activities specific to the subject or subjects they taught, according to the National Center for Education Statistics (NCES) School and Staffing Survey.[36]

Monitoring Student Progress in Mathematics and Science

All states require standardized tests to be administered to students from elementary, middle, and high school. Under NCLB, all states and schools must show that they are making adequate yearly progress toward the goal of all students meeting state-set proficiency levels. However, states may choose their own assessments, and few states administer the same test. The stakes are high for schools; those that do not show adequate yearly progress through standardized tests face interventions. For students, there are rarely high-stakes tests in elementary and middle school. However, in 2010, students in 25 states were required to pass high school exit exams for a standard diploma.[37]

The National Assessment of Educational Progress (NAEP) is the only nationally representative and continuing assessment of what U.S. students know and can do in various subject areas. NAEP has been collecting nationally representative data since 1969 and state representative data since the early 1990s. Since 1969, assessments have been conducted periodically in reading, mathematics, science, writing, U.S. history, civics, geography, and the arts. While the sample for this national assessment is large and represents states, the assessment is not designed to yield results for individual students or schools; no stakes are attached to the results.

Other standardized testing that takes place throughout the United States includes the Scholastic Assessment Test and American College Testing Assessment, both of which are commercial tests developed and administered by private organizations, taken primarily by upper high school students, and used in the college or university admission process. Admission to institutions of postsecondary education is not solely dependent on test scores; rather, most schools' admissions offices look at a number of factors, including a student's class rank, grade point average, and extracurricular activities. Some postsecondary institutions, including most two-year community colleges, do not require these test scores for admission.

A variety of grading systems are used in U.S. education, and there is no nationally mandated grading system. Decisions regarding which grading system to use are generally left up to individual institutions or individual teachers.

In public schools, grade reports typically are issued each quarter or approximately every nine weeks. Semester grades and yearly grades also are given in many districts. Usually, only one final grade may appear on a middle school or high school transcript, representing the student's performance in a course for the entire school year. High school transcripts that show courses taken and grades earned are used to establish whether students have met the state's graduation requirements. Transcripts also are used in college entrance applications as a record of academic performance.

The monitoring of individual students' long-term progress is generally shared by students, parents, and schools, except in cases in which students are identified as having special needs. In this case, the school district and school are responsible for monitoring student progress toward educational goals.

Impact and Use of TIMSS

Since the late 1990s, TIMSS has played a role in U.S. education policy discussions, has informed curricular reform efforts in the states, and has been the principal vehicle for international benchmarking by the states. Moreover, public interest in TIMSS has remained high, as measured by requests of TIMSS data from NCES.

In the late 1990s, when the results of the Third International Mathematics and Science Study were released, TIMSS became a standard policy citation to emphasize that U.S. student performance in mathematics and science was not leading the world. Between 1999 and 2002, state and national educational reformers across the country regularly used the results of TIMSS 1995 and TIMSS 1999 to make this point in editorials and articles.[b] During these years, over three dozen congressional statements, debates, and bills cited TIMSS results to justify the need for passage of specific education bills or to call for reforms in education to keep the U.S. internationally competitive.[c] In 2002, the U.S. Congress passed two major reforms of U.S. educational legislation—the No Child Left Behind Act and the Education Sciences Reform Act—both of which referred to TIMSS and made exceptions in the law to ensure continued national and state participation in TIMSS.[d] Since 2002, various national associations representing the interest of state governors and chief state school officers have used TIMSS results to advocate for international benchmarking by the states.[38] Non-profit education reform organizations have used TIMSS results to support their agendas for the states to improve graduation rates, academic standards, and accountability.[39]

In recent years, advocates have successfully used TIMSS results to improve education in the areas of science, technology, engineering, and mathematics (STEM). For example, a 2008 report to the U.S. Congress on promoting STEM education relied on comparisons of U.S. achievement in TIMSS with that of other nations as a basis for understanding the current status of mathematics and science education and as a justification for promoting further investment in STEM programs.[40] In addition, a 2011 documentary from Michigan State

b See results of search for "TIMSS" on LexisNexis and the Education Resources Information Center (ERIC) for years 1999–2002.

c See results of searches for "TIMSS" under legislative sessions 106 through 109 at http://thomas.loc.gov/home/LegislativeData.php.

d The No Child Left Behind Act (P.L. 107–110, Jan. 8, 2002) refers to TIMSS in Sec. 2202 (Grants For Mathematics And Science Partnerships) when it permits states seeking specific grants to use the results from "an International Mathematics and Science Study assessment" as a substitute for state mathematics and science assessment results for measuring "improved student academic achievement"; and makes an exception for federal funding of TIMSS in Sec. 9529 (Prohibition On Federally Sponsored Testing) (www2.ed.gov/legislation/esea02/107-110.pdf). The Education Sciences Reform Act of 2002 (20 USC Sec. 9543, P.L. 107-279) refers in Part C, Sec. 153 to TIMSS as a specific example of the type of data on educational activities and student achievement that the NCES is mandated to collect to compare the achievement of U.S. student with their peers in foreign nations (http://www.ed.gov/policy/rschstat/leg/PL107-279.pdf).

University focused on the role that TIMSS plays in monitoring the future progress of STEM programs in the United States.[41]

TIMSS data on curricula in top-performing nations have informed curricular reform efforts in various states. For example, the Oregon Department of Education's revision of its state K–8 mathematics content standards in 2007 notes that they examined the curriculum coverage in top-performing TIMSS countries and focused on the content included by at least two-thirds of the top-performing countries.[42] North Carolina cited TIMSS "recommendations" as informing its 2003 revisions of its mathematics standards and its 2004 revision of its science standards.[43, 44] Similarly, Massachusetts cited TIMSS as a source informing its 2006 revision of the state's "Science and Technology/Engineering Curriculum Framework."[45]

TIMSS curricular data also has played a role in the Common Core State Standards (CCSS) Initiative's successful effort to develop a clear and consistent framework to guide teaching practices for mathematics in every state. Experts who guided the development of the CCSS cited conclusions from TIMSS in their research, especially focusing on the curriculum of high-performing countries such as Singapore.[46] In 2010 and 2011, 43 states and the District of Columbia adopted the CCSS Initiative's mathematics curriculum (described in the "Mathematics Curriculum in Primary and Lower Secondary Grades" section of this chapter), and many reference TIMSS among the guiding sources for their new standards.[e] In its fact sheet on adopting the new standards, the Oregon Department of Education noted, "the CCSS were modeled after international standards, which allows for a shift away from the 'mile-wide, inch-deep' curriculum and prepares students with the skills they need to be competitive in the global marketplace."[47]

TIMSS also has been the principal vehicle for international benchmarking by the states. In the first administration of TIMSS in 1995, five U.S. states participated as benchmarking participants to gain insight as to how their students compared with their peers around the world. Since then, 13 more states have taken part in TIMSS as benchmarking participants and the original five states have all participated in benchmarking at least once again. In 2011, nine U.S. states were TIMSS benchmarking participants.

Another way to assess public interest in TIMSS is by the number of people looking for TIMSS information on the NCES website, which is the primary U.S.

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Department of Education internet source for information on TIMSS. Between 2009 and 2011, the number of visits to the NCES website for information about TIMSS increased from approximately 25,000 visits per month to approximately 33,000 visits per month. In December 2010, the TIMSS International Data Explorer (IDE) debuted, allowing users online to create statistical tables and charts with TIMSS data. In its first year online, there were over 85,000 views of the TIMSS IDE website.

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Republic of Yemen

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Introduction

Overview of the Education System

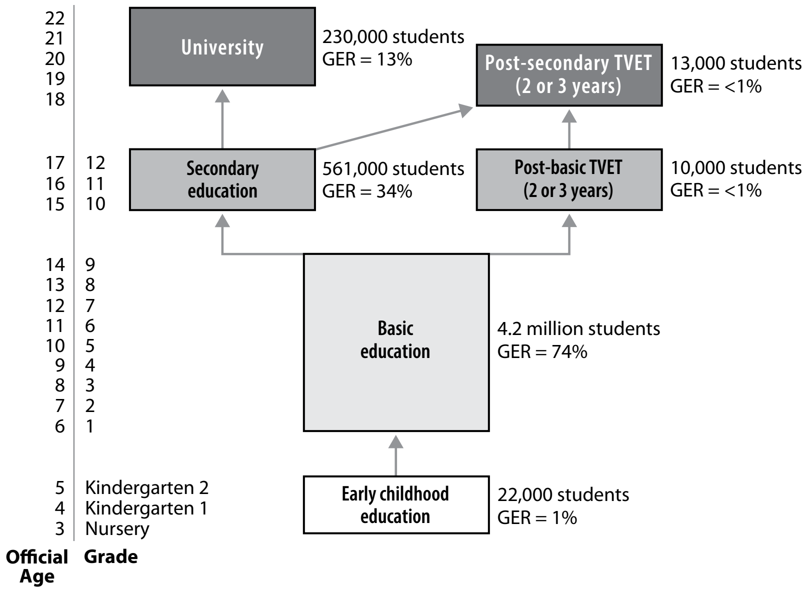
The present structure of Yemen's formal education system has been in place since the unification of North and South Yemen in 1990. Formal education currently encompasses nine years of compulsory Basic Education (Grades 1–9) followed by three years of General Secondary Education of which the first year, Grade 10, is general (i.e., all students study all curriculum subjects). From Grade 11 on, students choose between two tracks: Literary or Scientific. Literary students study humanities subjects. Students in the Scientific track study biology, chemistry, mathematics, and physics in addition to the common subjects. Students in both tracks study Quran sciences, Islamic education, Arabic, and English. In lieu of General Secondary Education, a two- to three-year Post-basic Technical Vocational Education and Training (TVET) track also is offered.

While early childhood education is part of Yemen's formal system, it generally only exists in the private sector, which may explain the low gross enrolment rate (GER) of only one percent at this stage (see Exhibit 1).

Yemen's Ministry of Education (MoE) oversees Basic Education and General Secondary Education nationally. MoE is responsible for strategic planning, training, and curriculum development, including textbook development and production. Two other ministries are responsible for higher education (university) and technical/vocational education. MoE delegates managerial roles to local education offices (LEOs) in Governorates and Districts, who work with local councils to determine financial allocations and staffing based on guidelines set by the respective ministries at the national level.

Since unification in 1990, Yemen's general education curriculum has changed twice. Immediately following unification, an interim curriculum was enacted, combining elements of the curricula taught in former North and South Yemen. This temporary curriculum remained in place until MoE designed and implemented a new curriculum for Grades 1–6 in 2000, for Grades 7–9 in 2001,

Exhibit 1: Structure and Enrollments in the Yemeni Education System[1]



for Grades 10 and 11 in 2002, and for Grade 12 in 2003. Yemen's current curriculum for Grades 1–12 consists of a detailed set of documents that include general curriculum principles, syllabi and overall learning objectives for each subject, and detailed and clearly sequenced content, skills, and objectives for each grade.[2]

Languages of Instruction

Arabic is the official language of Yemen[3] and of Yemeni public education. However, private sector schools commonly have two tracks—one in which all subjects are taught in Arabic and the other in which science and mathematics are taught in English, with syllabi and textbooks borrowed from international education systems.

In 2007, the Republic of Yemen's population was estimated at 22.3 million,[4] the majority (71% in 2004) being rural. In addition, 70 percent of Yemenis (15 million) were under the age of 25, over one-third of whom (approximately 5.6 million) were age 6–14, corresponding to the age cohort for Basic Education (Grades 1–9).

From the early 1990s to the early 2000s, population growth rates decreased from 4.8 percent to 3.0 percent annually. Nevertheless, fertility rates and population growth rates in Yemen remain among the highest in the world. If this current pattern of growth continues, the country's population is expected to more than double to 47 million by 2040.

Mathematics Curriculum in Primary and Lower Secondary Grades

The mathematics curriculum for Grades 1–6 includes the following:

- Numbers and Algebra—Addition, subtraction, multiplication, and division of whole numbers, fractions, and decimals; computing, comparing, and ordering of numbers; approximation and estimation; ratio, proportion, and percentage; factors and prime numbers; square and cubic roots; patterns and powers; practical problem solving.
- Geometry and Measurement—Acute, straight, right, and obtuse angles; vertical angles; parallel and perpendicular lines; properties of geometric shapes (quadrilaterals, triangles, and circles), and solids (cubes, rectangular parallelepipeds, spheres, cones, and cylinders); congruent triangles; measures of length, angle, volume, time, and money; areas and perimeters of triangles, circles, and quadrilaterals; volume of cubes; and practical problem solving.
- Data and Statistics—Summarizing, classifying, and organizing data; and presenting information in pictograms, tables, and diagrams.

The mathematics curriculum for Grades 7–9 includes the following:

- Algebra and Numbers—Addition, subtraction, multiplication, division, and properties of rational, irrational, and real numbers; square and cubic roots of rational numbers; perfect squares; factoring using greatest common factor; sets, relations, and linear functions; linear equations in one and two variables; and linear inequalities in one variable.
- Geometry—Adjacent, complementary, and supplementary angles; angles associated with parallel and perpendicular lines; angle sum theorem, congruence, and equivalence of triangles; the Pythagorean theorem; properties of circles; two dimensional Cartesian coordinates; reflection, translation, rotation, and magnification in the Cartesian plane; areas and volumes of rectangular parallelepipeds, cubes, prisms, cylinders, pyramids, cones, and spheres.
- Trigonometry—Trigonometric ratios of 30-, 45-, and 60-degree angles.
- Data and Statistics—Presenting and interpreting data in tables, graphs, and diagrams using information from local sources; simple experiments; and measures of central tendency (mean, median, and mode).

Science Curriculum in Primary and Lower Secondary Grades

The science curriculum for Grades 1–6 includes the following:

- Living Things—The five senses and their functions; major human body structures and systems (digestive, respiratory, circulatory, nervous, and urinary); human health and nutrition; relationship between cells, tissues, organs, and systems; interdependencies of living things in ecosystems; animals (classification, nutrition, reproduction, motion, defense mechanisms, and habitats); domestic and wild animals; vertebrates (characteristics and economic importance); invertebrates (characteristics, economic importance, and their impact on human health); micro-organisms and parasites (bacteria, viruses, and parasites, and their impact on human health); plants (major body structures, nutrition, growth, respiration, reproduction, and the food chain).
- Matter and Its Properties—Definitions, properties, states, and structure of matter.
- Energy—Types, resources, renewable and non-renewable sources, uses, and wise consumption; heat (sources, effects of heat on objects, and temperature measurement); electricity (static electricity, alternating current, electrical circuits, uses in the home, and basic safety); magnetism (types, properties, attraction and repulsion, magnetic force, and uses); light (sources, reflection and refraction, and spectra); sound (transmission and comparison to light); and power and work.
- Earth and Atmosphere—Structure of the Earth; the Earth's crust, rocks, and soil; water (location, uses, water cycle in nature, water pollution); air (properties, components, atmospheric pressure, and pollution); and weather and climate.
- Force and Motion—Types of force (friction, gravity, and magnetic); work and motion; and simple machines.
- Solar System and Space—The sun, moon, and stars; the sun as a source of light and heat; rotation and revolution of the Earth; revolution of the moon (months and phases of the moon); eclipses (solar and lunar); and telescopes.
- Cleanliness at Home and at School—Cleaning tools, and cleanliness and health.
- Safety—At home, in school, on the street; traffic safety; and first-aid.

The science curriculum for Grades 7 to 9 includes the following:

- Biological Diversity—Diversity of living organisms and environment (unicellular organisms, bacteria, fungi, algae, and insects), ecosystems, adaptations of living organisms in different environments (aquatic, forest, and desert), and conservation and sources of biological diversity.
- Life Processes—Cells (plant, animal, and functions), microscopes, the five senses (tissues, organs and, systems associated with the senses), the body's systems (skeletal, nervous, digestive, circulatory, respiratory, excretory, and reproductive), and the properties of blood.
- Human Health—Viral diseases (especially common childhood diseases), communicable inflections and prevention, diseases associated with malnutrition, parasitic diseases, common cancers, and first-aid.
- The Earth and the Universe—The Earth in the context of the solar system and universe, planetary motion, night and day, the four seasons; eclipses of the sun and moon, space ships and satellites, and humans in space.
- The Earth and Its Resources—Water (the water cycle, water and the food chain, water and energy production, water and agriculture, and water pollution and purification); and land (soil, rocks, agriculture, building materials, ores, and pollution).
- Matter—Elements, compounds, mixtures, states of matter, and separation techniques; physical changes (melting, freezing, and evaporation); chemical changes (iron rust, soap manufacturing, and industrial pollution); periodic table, chemical symbols, metals, and non-metals; atomic structure, atomic number, and atomic mass; ions, electronic configuration, and chemical bonds; chemical reactions and equations; and applications (water purification and environmental protection from industrial pollution).
- Force—The metric system and derived units; forces and their effects (work, power, and energy); tools; pressure, density, buoyancy, and their applications.
- Energy—Types of energy, heat, the sun as a source of energy and heat, and energy transfer.
- Electricity and Magnetism—Static electricity and electrical discharge; alternating current; generators and motors; electric circuits; conservation of electricity; safety; and magnetism, magnetic fields, types of magnets and electromagnets.

- Sound and Light—Sound and sound waves, sound properties, and echoes; applications of sound; the human voice; light and light waves; the electromagnetic spectrum (radio waves, infrared, visible, and ultraviolet light, x-rays, and gamma-rays) and transmission of information using the electromagnetic spectrum; laws of reflection, mirrors, and images; law of refraction, total internal reflection, and mirages; lenses and sight; optical tools (cameras and simple microscopes); and eye safety.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

From Grades 1–10, mathematics and science are treated as general subjects. Beginning in Grade 11, however, they are separated from humanities subjects into their own track called "Scientific Section."

The school week is composed of six half-days (8:00 AM to 12:45 PM), each comprised of 5.5 periods, on average. In Grades 1–3, instructional time for mathematics is five periods per week, with each period averaging 42.5 minutes. In Grades 4–9, time dedicated to mathematics instruction increases to six periods per week. Instructional time for science is two periods per week for Grades 1–3, three periods per week for Grades 4–6, and four periods per week for Grades 7–9.

Instructional Materials, Equipment, and Laboratories

Teachers mainly rely on instructional textbooks from MoE, which also supplies some teaching aids, such as charts. Student laboratories are found in most secondary schools, and many schools in larger cities have established computer labs with development funding assistance from the private sector and international agencies.

Most Yemeni students do not have access to learning materials, libraries, or reference materials (at home or outside), particularly in rural areas.[5] In the 2007–08 school year, 10 percent of schools nationwide had libraries;[6] of these, five were in rural schools and 48 were in urban schools.

Use of Technology

Learning and teaching resources, including technology resources, are scarce in Yemeni public schools. As a result, there is little systematic instructional use of technology in schools.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Presently, Yemeni public school teachers have three tiers of specialization. Grades 1–6 are typically taught by general classroom teachers prepared at teaching training institutes (TTIs). Grades 7–9 are taught by university graduates who are assigned subjects based on their area of study (e.g., science teachers have biology, physics or chemistry degrees, and social studies may be taught by a geographer or historian). In Grades 10–12, science is taught as separate subjects by teachers who specialized in the respective field (e.g., biology, chemistry, physics).

Homework Policies

Homework is an integral part of classroom assessment and carries a percentage weight in determining a student's marks. In Grades 1–8 and 10–11, homework constitutes 8 percent of the cumulative grade determining student promotion at the end of the school year. At Grades 9 and 12, homework is one of the factors contributing to a student's total final assessment score, which accounts for 20 percent of the cumulative grade determining entry to or graduation from secondary school (at Grades 9 and 12, respectively).

Teachers and Teacher Education

The history of modern education in Yemen is only several decades long. In the 1970s through the 1980s, Yemeni schools were staffed by teachers from other Arab countries, mainly from Egypt, in addition to Syria and Sudan. The number of Yemeni teachers has since increased as a result of the following factors:

1. A nationalization policy in the context of a massive system expansion;
2. Differing needs in rural and urban areas (mismatch between recruitment policies and needs);
3. Availability of large numbers of graduates from Faculties of Education; and
4. Weak sector governance.[7]

The qualification of Yemeni teachers varies dramatically. Sixty-five percent of teachers in Grades 1–6 do not have a post-secondary diploma, 21 percent have a post-secondary diploma, and 14 percent have a university or graduate degree. Thirty-five percent of teachers in Grades 7–12 do not have a university or graduate degree, and 65 percent have a university or graduate degree.

Monitoring Student Progress in Mathematics and Science

School-based assessment is used to monitor student progress in Grades 1–8 and 10–11. Teacher-administered monthly assessments constitute 40 percent of a student's overall assessment, and include oral quizzes, pencil-and-paper quizzes, homework, and classroom conduct (each comprising 20, 40, 20, and 20% of teacher-administered assessment, respectively). Mid-year and end-of-year examinations are administered by school administrators and contribute equally to the remaining 60 percent of student's final mark. The examination at the end of Grade 9 is the primary determiner of entry into secondary school, and the examination at the end of Grade 12 determines graduation.

However, evaluation of Yemeni teacher examinations by the International Bank of Reconciliation and Development/The World Bank and the Republic of Yemen has concluded that the system has "little value for the intended purposes" for the following reasons:

1. A lack of clear standards or benchmarks that specify student-learning outcomes for each subject;
2. A lack of teacher skills in designing reliable and effective tests;
3. Tests not promoting problem-solving and critical thinking skills, focusing instead on textbook memorization; and
4. Teachers rarely providing useful analyses of test results as feedback to students.[8]

A Higher Committee headed by the Vice Minister of Education is responsible for the general examination system for Grades 9 and 12. This system, however, has been found faulty. Namely, perceptions of abuse focus on the level of the examination center, at which committee members may be selected based on favoritism instead of qualifications.[9]

Impact and Use of TIMSS

Since 2005, when TIMSS 2003 International reports were disseminated and a new TIMSS Technical Team (TTT) was formed to manage Yemen's participation in the study, most Yemeni educators and educationalists have learned about TIMSS.

In reality, much is yet to be done. Rapid, substantial quality reform is a financial burden for a poor country still struggling to achieve universal basic education by 2015. However, following the first-ever analysis of national data of TIMSS 2007, two written proposals have been presented to MoE leadership.

The first of these proposals was the Foundation Grades Initiative, aimed at improving performance of Yemen in TIMSS 2011. It suggested introducing a new organization to classrooms in Grades 1–3, printing and dissemination of released TIMSS test items, and conducting a 70-school pilot of a new teacher education program. The latter may only be accomplished by MoE with support of the German Society for International Cooperation's General Education Improvement Program (GIZ, GEIP).[10]

The second proposal, the All Must Read by Grade 3 project, has the long-term goal of enhancing quality education, and called for a four-pillared reform: curriculum, teaching, class size and organization, and learning assessment. The project is still in its initial stage, however, some work by MoE and TTT is underway to establish a National Assessment System for Grades 1–6, again, with support of GIZ, GEIP. A pool of more than 2000 test items in Arabic, mathematics, and science has been drafted to correspond to objectives of the Yemeni curriculum. The assessment will test students in Grades 4 and 7, with the field test of items for Grade 7 scheduled for February 2012.

Finally, according to the World Bank, "an independent Center for Measurement and Evaluation is in early stages of development. Participating in TIMSS enabled Yemen to gain experience in conducting learning assessments using modern scientific methodologies." [11]

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Benchmarking Participants

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Alberta Education

Introduction

Overview of the Education System

Alberta, like other provinces and territories in Canada, is responsible for operating its own educational system, although Alberta collaborates with a number of provinces and territories through the *Western and Northern Canadian Protocol for Collaboration in Education* (WNCP).[1] The WNCP partnership was established in 1993 and renewed in 2011 by the Ministers of Education in Alberta, Saskatchewan, Manitoba, Yukon, Northwest Territories, and Nunavut. These provinces and territories work to achieve shared strategic goals in the broad area of kindergarten to Grade 12 curricula (curriculum frameworks, resources, and assessment) while continuing to recognize and maintain jurisdictional autonomy on educational matters.[2]

The province's programs of study identify what students are expected to learn and be able to do in all subject areas and grade levels, from kindergarten to Grade 12. School authorities may select instructional materials that will assist students in achieving the identified outcomes. Students must take certain required courses; however, they also can select from a number of optional courses that may differ in each school.[3]

Alberta generally groups schools into the following three levels: primary (Grades 1–6), junior high (Grades 7–9), and senior high school (Grades 10–12). Several school choices exist in Alberta, including public, separate, Francophone, private and charter schools. In Alberta, separate schools, which can be either Roman Catholic (in most cases) or Protestant, are all funded on the same basis as public schools. Charter schools must be approved by the Minister of Education and are established to provide innovative, different, or enhanced programs to improve student learning. Students also have access to a number of unique and innovative programs including home education, online or virtual schools, outreach programs, and alternative programs. Students in Alberta are required to attend school from ages 6–16, although parents also may choose to homeschool their children.[4, 5]

Early Childhood Services (ECS) programs serve children prior to Grade 1 and include kindergarten. Attendance at early childhood programs such as kindergarten is voluntary and may be offered by public or private schools, or other private institutions. Students attending kindergarten should have access to at least 475 hours of instruction per year.[6]

Languages of Instruction

In Alberta, the primary languages of instruction are English and French, with the majority of students receiving English instruction. Alberta's ministry of education, Alberta Education, encourages school authorities to provide opportunities for all students in the province to learn French—through alternative French programs, such as French Immersion and French as a second language courses—and for Francophone students to study in their first language.[7] The majority of non-language arts programs of study developed provincially by Alberta Education are in both English and French for kindergarten to Grade 12.

A number of provincially developed language programs are offered, including optional programs in First Nations, Métis, and Inuit (FNMI) languages, such as Blackfoot and Cree.[8] Several bilingual and immersion programs also are offered in languages such as Arabic, Chinese, Ukrainian, German, and Spanish. Bilingual programs provide instruction in the target language for up to 50 percent of the school day. In addition to a language arts course to provide explicit language instruction in the target language, instruction for one or more subject areas, such as mathematics and social studies, also is provided in the target language.

Alberta Education has programs of study as well as learning and teaching resources to support the following international languages: Chinese, German, Italian, Japanese, Punjabi, Spanish, and Ukrainian, as well as Cree and Blackfoot. Classroom assessment materials have been developed for the following languages for Grades 4–6: Cree, Chinese, French, German, Japanese, Punjabi, Spanish, and Ukrainian. Where possible, school authorities throughout the province are encouraged and supported to make second language programs available.

The population of English language learners in Alberta continues to increase by an average of 14 percent each year. In order to continue to meet the needs of these students, preprimary, primary, and junior high schools (Kindergarten–Grade 9) with identified English language learners may refer to the following resources: *English as a Second Language Kindergarten to Grade 9*

Guide to Implementation, and *Working with Young Children Who Are Learning English as a New Language*.[9] The *Alberta K–12 ESL Proficiency Benchmarks* have been developed to guide appropriate ESL programming and to support teachers in assessing and reporting the progress of English language learners.[10] Launched in August 2011, Teaching Refugees with Limited Formal Schooling is a website that also provides information and resources to school authorities across Alberta and elsewhere to promote effective school-based programming for students from refugee backgrounds.[11]

Mathematics Curriculum in Primary and Lower Secondary Grades

Mathematics education in Alberta aims for students to become mathematically literate adults and continue on the path of lifelong learning in mathematics. The following components of mathematics instruction are critical in order for students to meet the goals of mathematics education: [12]

- Communication—Using a variety of communication forms to help students make sense of and make connections among the various representations of mathematics ideas;
- Connections—Connecting students' own experience to relevant and meaningful situations, which help students view mathematics as being useful, relevant, and integrated;
- Mental Mathematics and Estimation—Improving computational fluency by developing efficiency, accuracy, and flexibility using mental mathematics and estimation;
- Problem Solving—Learning through problem solving, exploring real-life problems, and developing solution strategies to help students deepen conceptual understanding, discover innovative and creative solutions, and engage more fully with mathematics;
- Reasoning—Developing mathematical reasoning to help students think logically and make sense of mathematics; and providing opportunities for students to develop confidence in their reasoning abilities through mathematical experiences that promote the use of logical processes to analyze problems, reach conclusions and justify or defend them;
- Technology—Using technology to explore and create patterns, examine relationships, test hypotheses, and solve problems in order to discover and reinforce mathematical concepts; and

- Visualization—Fostering visualization through the use of concrete materials, technology, and a variety of visual representations, which provide opportunities for students to understand mathematical concepts and make connections among them.

Student learning outcomes, which promote the development of the mathematical processes, are organized into strands that form the foundation of the program of study. The following four strands reinforce the inter-relationship of mathematical concepts and skills for the entire kindergarten to Grade 9 mathematics program:

- Number—Students develop number sense, use numbers to describe quantities, represent numbers in multiple ways, and demonstrate proficiency with calculations, and solve problems involving arithmetic operation(s).
- Patterns and Relations—Two sub-strands comprise this strand: Patterns and Variables, and Equations. Students describe the world and solve problems using patterns and represent algebraic expressions in multiple ways.
- Shape and Space—Three sub-strands comprise this strand: Measurement, Three-Dimensional Objects and Two-Dimensional Shapes, and Transformations. Students use direct and indirect measurement to solve problems, describe the characteristics of three-dimensional objects and two-dimensional shapes and analyze the relationships among them, and describe and analyze the position and motion of objects and shapes.
- Statistics and Probability—Two sub-strands comprise this strand: Data Analysis, and Chance and Uncertainty. Students collect, display, and analyze data to solve problems, and use experimental or theoretical probabilities to represent and solve problems involving uncertainty.

Science Curriculum in Primary and Lower Secondary Grades

Alberta Education's elementary science program (Grades 1–6) engages students in a process of inquiry and problem solving in which they develop both knowledge and skills.[13] The elementary science program of study is based on the following principles:

- Children's curiosity provides a natural starting point for learning;

- Children's learning builds on what they currently know and can do;
- Communication is essential for science learning;
- Students learn best when they are challenged and actively involved; and
- Confidence and self-reliance are important outcomes of learning.

The elementary science program consists of a series of five topics for each grade, which may be developed as discrete units or linked to other topics or other subject areas. These topics serve as a vehicle for developing questions, problems, and issues that give purpose for learning within meaningful contexts. For each grade, expected skills and attitudes are identified, with two main areas of skill emphasis: Science Inquiry, and Problem Solving with Technology. Science Inquiry focuses on asking questions and finding answers based on evidence. Problem Solving with Technology focuses on finding ways of making and doing things with available tools and materials in order to meet a given need. The outcome of inquiry is knowledge, whereas the outcome of problem solving is a product or process.

The junior high science program of study (Grades 7–9) is guided by the vision that all students have the opportunity to develop scientific literacy.[14] The goals of this program work towards achieving this vision by doing the following:

- Encouraging students at all grade levels to develop a critical sense of wonder and curiosity about scientific and technological endeavors;
- Enabling students to use science and technology to acquire new knowledge and solve problems, in order to improve the quality of their own lives and the lives of others;
- Preparing students to critically address science-related societal, economic, ethical, and environmental issues;
- Providing students with a foundation in science that creates opportunities for them to pursue progressively higher levels of study, and prepares them for science-related hobbies appropriate to their interests and abilities; and
- Enabling students of varying aptitudes and interests to develop knowledge of the wide spectrum of careers related to science, technology, and the environment.

To support the development of science literacy, each unit of study for each grade is structured around the following four foundational areas that address the critical aspects of science and its application:

- Foundation 1: Science, Technology, and Society—Students develop an understanding of the nature of science and technology, the relationships between science and technology, and the social and environmental contexts of science and technology;
- Foundation 2: Knowledge—Students construct knowledge and conceptual understanding in life science, physical science, and Earth and space science, and apply this understanding to interpret, integrate, and extend their knowledge;
- Foundation 3: Skills—Students develop the skills required for scientific and technological inquiry, for problem solving, for communicating scientific ideas and results, for working collaboratively, and for making informed decisions; and
- Foundation 4: Attitudes—Students will be encouraged to develop attitudes that support the responsible acquisition and application of scientific and technological knowledge to the mutual benefit of self, society, and the environment.

Each unit has an identified Science, Technology, and Society emphasis through which the other foundations can be developed. Units with a nature of science emphasis focus on the processes by which scientific knowledge is developed and tested and on the nature of scientific knowledge itself. The skills emphasized in these units are scientific inquiry skills. The science and technology emphasis encourages students to seek solutions to practical problems by developing and testing prototypes, products, and techniques to meet a given need. Problem-solving skills, in combination with scientific-inquiry skills are emphasized. Finally, in units with a social and environmental emphasis, students focus on issues and decisions relating to applications of science and technology. In these units, emphasis is placed on using research and inquiry skills to inform the decision-making process.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Materials, Equipment, and Laboratories

Alberta Education authorizes resources that support teaching the learning outcomes of the province's programs of study. These resources are available in English and French and are reviewed to ensure they meet the following stringent criteria: curriculum congruency, and instructional and technical design; recognizing diversity and promoting respect; Canadian content; and

First Nations, Métis, and Inuit perspectives. Authorized resources are not mandated in program delivery. School boards have the responsibility to develop or acquire resources for use in their schools and may choose to develop their own instructional materials or select resources that may or may not include those authorized by Alberta Education.

Resources for mathematics and science instruction include basic student resources, student support resources, and teaching resources. Basic student resources address the majority of general and specific outcomes of the programs of study, while support resources address only some outcomes. Resources are available in various forms, including digital, print, audio, video, or hands-on materials, such as manipulatives.[15]

In science programs, hands-on activities are a fundamental part of learning. In early grades, students' exploratory activities with materials provide the starting point for concept and skill development. In later grades, students learn the techniques of controlled investigation and experimentation and, through practice, develop science inquiry and problem solving skills. Laboratory activities provide the starting point for understanding the nature of science and the interplay of evidence and theory.[16] School districts are responsible for maintaining science materials and laboratories, and for ensuring that all staff are properly trained in safety practices.

Use of Technology

In Alberta, provincial programs of study, particularly those in language arts, social studies, science, and mathematics, provide information and communication technology (ICT) learning outcomes in both English and French. Students develop the ability to use a variety of processes to critically assess information, manage inquiry, solve problems, do research, and communicate with a variety of audiences within the context of other subject areas. Students learn about the impact of information and communication technology on themselves and society, how to use their knowledge and skills, and to apply a number of technologies in real-life situations. Assessment of student progress in these areas is integrated into and aligned with other assessments.

Further, Alberta Education supports LearnAlberta.ca, a website that provides online learning and teaching resources directly tied to classroom learning. These high quality digital resources are designed for teachers, parents, and students, and are accessible in both English and French.[17]

Technology is one of the tools students use to learn mathematics. The mathematics program of study specifies that some outcomes should be learned and assessed with technology. Students are expected to experience a variety of technologies in their mathematics program and school districts are required to ensure access to technology for all students.

Grades at Which Specialist Teachers for Mathematics and Science are Introduced

Post-secondary institutions in Alberta differ in how they structure their undergraduate pre-service teacher education. In most cases, primary school pre-service teachers are trained as generalists with a minor in a subject area, often language arts. Therefore, students generally encounter their first mathematics or science specialist teacher in the first year of junior high school (Grade 7), and the likelihood of students receiving instruction from a specialist increases dramatically as students move into the higher grade levels in high school.

Homework Policies

Alberta Education does not have any mandated homework policies in place, and school authorities are allowed to make their own decisions regarding homework assignments for students.

Teachers and Teacher Education

Teacher Education Specific to Mathematics and Science

Elementary and secondary school teachers must complete at least four years of post-secondary education to receive a bachelor's degree in education. At least one supervised practicum in the field is mandatory. For certification purposes, all primary school teachers are required to complete a minimum of three semester hour credits in mathematics and three semester hour credits in science within their post-secondary education. Each university requires students take a specific number of mathematics or science courses in order for a degree to be granted in the specific area of focus. For certification purposes, if secondary teachers choose mathematics or science as a teachable subject area, they must complete a minimum of 24 semester hour credits in one of these areas. Curriculum courses are offered to teacher education students, with several instructional courses taken by those specializing in mathematics and science. After receiving a degree and upon confirmation of competency by a Dean of Education, a teacher is granted an interim professional teaching certificate from Alberta Education. After two years, and upon recommendation from a school authority, based on evaluation of teacher performance in meeting enhanced competency standards, a teacher may be granted a permanent professional teaching certificate.[18]

In order to attract and retain graduating teachers to northern Alberta communities and to address the shortage of teachers in a number of specialty areas, including mathematics and the sciences, a two-year financial support pilot program in the form of a teacher scholarship has been in effect over the last two years. In exchange, recipients agree to a service commitment for a specified length of time in one of Alberta's northern school jurisdictions. Scholarship recipients also may receive practicum funding to assist with costs associated with travel and basic living expenses while fulfilling their commitment.[19] Funding for this scholarship and practicum is provided by Alberta Education and recently has been extended for a further two years.

Requirements for Ongoing Professional Development

In-service teacher education is overseen by each school district and by regional consortia that coordinate professional development opportunities. Teachers in the province have opportunities to explore more hands-on and personalized types of learning environments (offered in both English and French) to enhance their professional development needs in a number of subject areas including the revised mathematics and science curriculum.[20]

In addition to traditional face-to-face professional development opportunities, teachers also may enhance their learning through a number of technology-supported methods, including online learning communities (e.g., Moodles or Wikis). Alberta Education also supports teachers' professional development learning opportunities at teacher conventions and specialist council conferences. Furthermore, Alberta Education liaises with the Alberta Teachers' Association, the professional organization representing teachers in the province, to offer professional development opportunities to teachers. Teacher conventions are held each year to provide opportunities for teachers to become acquainted with the latest research and news with regards to their areas of instruction.

Monitoring Student Progress in Mathematics and Science

Monitoring student progress in mathematics and science is part of daily classroom instruction and primarily is accomplished through classroom assessment including, but not limited to, teacher observations, portfolios, informal mathematics and science inventories, marked assignments, student-teacher communications, and various formative and summative teacher-made quizzes and tests. Alberta mandates that teachers communicate to parents about student progress in relation to the grade levels of the provincial program of study for language arts and mathematics through various means, including report cards, parent-teacher conferences, blogs, and emails.[21]

Students take provincial achievement tests (PATs) to help teachers maintain consistent standards across the province and to obtain a clear understanding of whether students have achieved the expected learning outcomes as described in the provincial programs of study for each grade level. PATs are administered annually in English language arts and mathematics to all students in Grades 3, 6, and 9, and in science and social studies to students in Grades 6 and 9. Additionally, students registered in alternative French programs are required to take a PAT in *Français*/French language arts. As of June 2008, teachers are required to report to parents the preliminary teacher ratings for the machine-scored component of Grades 6 and 9 PATs.

In Grade 12, students must take provincial diploma examinations (DIPs) in order to receive high school diplomas. Diploma examinations are administered in the following subjects: mathematics, English language arts, biology, chemistry, physics, science, social studies, and French language arts. Each examination grade comprises 50 percent of a student's final grade in that subject.

Following each PAT or DIP administration, detailed reports are generated at the district, school, class, and student level based on data collected from the assessment. These reports are then sent to schools and teachers to help them identify students' strengths and areas requiring improvement.[22, 23]

In addition to a variety of informal mathematics and science inventories, teachers use an array of standardized tests to assess mathematics and science achievement. Commonly used tests include the following: the Brigance Comprehensive Inventory of Basic Skills-Revised (CIBS-R); the Canadian Achievement Test; the Canadian Test of Basic Skills (CTBS); the Wechsler Individual Achievement Test, Canadian Version; and the Woodcock-Johnson III Tests of Achievement.

Impact and Use of TIMSS

Alberta has participated in TIMSS since 1995. The province also has participated in a number of other international studies of achievement including the International Association for the Evaluation of Educational Achievement's

(IEA) Progress in International Reading Literacy Study (PIRLS) since 2006, and the Organisation for Economic Co-operation and Development's (OECD) Programme for International Student Assessment (PISA) since 2000.[24]

Through its active involvement in these international studies and the ensuing trend analyses of student achievement levels, Alberta is able to identify and understand its students' strengths and weaknesses in an international context compared to other participating countries and jurisdictions. Alberta also is able to triangulate standards in its own provincial assessments and programs of study. Typically, whenever a noticeable change is found in student performance on provincial assessments, student achievement results on an international assessment will be used as an external measure to confirm whether such a change is substantive or if the results may be attributed to any shift in provincial assessment standards and/or curricula.

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Province of Ontario

Ontario Ministry of Education

Introduction

Overview of the Education System

In Ontario, Canada, education is governed principally by the Education Act and its regulations, which set out the duties and responsibilities of the Minister and Ministry of Education, school boards, school board supervisory officers, principals, teachers, early childhood educators, parents, and students.[1] By law, the Ministry of Education has overall responsibility for the following: developing curriculum; allocating funds to school boards; setting policies and guidelines for school trustees, directors of education, principals, and other school board officials; and setting requirements for student diplomas and certificates.

Primary and secondary public education is free to all individuals qualified to be resident students. With the passage of the Education Amendment Act (Learning to 18) in 2006, students now are required to continue their education until they graduate or turn 18.[2]

Approximately 95 percent of Ontario's students are enrolled in publicly funded schools. Ontario has 72 district school boards: 31 English public schools, 29 English Catholic, 4 French public, and 8 French Catholic. In 2009–10, the publicly funded education system had approximately 2 million students enrolled in approximately 4,000 primary and 900 secondary schools. About two-thirds of Ontario's students were enrolled in public schools and one-third in Catholic schools. Approximately 5 percent of Ontario's students were enrolled in French-language schools. In addition, there were 22 provincial schools for students who are deaf, blind, or have severe developmental disabilities, as well as about 875 Ministry-recognized private schools that do not receive government funding. In Ontario, there are approximately 70,000 full-time equivalent primary school teachers and 44,000 full-time equivalent secondary school teachers.[3]

In 2010–11, Ontario began introducing full-day kindergarten with the goal of complete implementation by 2014–15. Full-day kindergarten is a child-centered and developmentally appropriate learning program for four- and five-year-olds. The purpose of the program is to establish a strong foundation for learning in the early years, and to do so in a safe and caring play-based environment that promotes the physical, social, emotional, and cognitive development of all children. While kindergarten is not mandatory, over 90 percent of eligible children are enrolled.

Children are required to begin school once they turn six years old. In Ontario, there are four education levels: Primary (Grades 1–3), Junior (Grades 4–6), Intermediate (Grades 7–10), and Senior (Grades 11 and 12). Grades 1–8 comprise the elementary level, and teachers at this level teach all subjects. In this level, students receive 25 hours per week of instructional time, though there is no mandated percentage of instructional time for subjects such as mathematics or science. Decisions regarding the amount of time spent on any particular area of the elementary curriculum (with the exception of French as a second language and daily physical activity) are made at the local level to allow educators choice in integrating subject content. Grades 9–12 comprise the secondary level. At this level, students earn credits through successful completion of courses, which are a minimum of 110 hours in length. In Grades 9 and 10, there are three program pathways: applied, academic, and locally developed compulsory. Students focus their pathways in Grades 11 and 12 according to their intended destination: university, college, or the workplace. Students working towards a secondary school diploma must complete three compulsory credits in mathematics, with at least one credit in Grades 11 or 12, and two compulsory credits in science, with an elective credit in science (in Grades 11 or 12), technological education, computer studies, or cooperative education.

Languages of Instruction

Ontario is multilingual and multicultural and has approximately 13.4 million inhabitants, representing 39 percent of Canada' population. The languages of instruction in the province are both English and French, with Section 23 of the Canadian Charter of Rights and Freedoms guaranteeing Francophones the right to a French-language education.[4]

According to 2006 census data, approximately 70 percent of Ontarians have English as their mother tongue, 4 percent have French, and 26 percent have a first language other than English or French. First nations, Métis, and Inuit peoples comprise close to 2 percent of the population.

In the English-language system, over 20 percent of Ontario's elementary students have a first language other than English. The government provides policy direction, programs, and funding support to school boards for students to acquire proficiency in the official languages of instruction, and Ontario has policies to support students in English as a second language and in English literacy development.

Mathematics Curriculum in Primary and Lower Secondary Grades

In 2005, the Ministry of Education released the revised *Ontario Curriculum, Grades 1–8 Mathematics* and *Le curriculum de l'Ontario de la 1re à la 8e année, Mathématiques.*[5, 6] The revised curriculum recognizes student diversity and is based on the belief that all students can learn mathematics and deserve the opportunity to do so. The curriculum supports equity by promoting the active participation of all students and by clearly identifying the knowledge and skills students are expected to demonstrate in every grade. It recognizes different learning styles and sets expectations that call for the use of a variety of instructional strategies and assessment tools. Further, it aims to challenge all students by including expectations that require them to use higher-order thinking skills and to make connections between related mathematical concepts and between mathematics, other disciplines, and the real world.

The French-language curriculum is developed, implemented, and revised in parallel with the English-language curriculum. A distinct feature of the French-language education system is the *Aménagement Linguistique* policy, which is intended to promote, enhance, and expand the use of the French language and culture in a minority setting and in all spheres of activity.[7]

The revised mathematics curriculum includes five strands or major areas of knowledge and skills: Number Sense and Numeration, Measurement, Geometry and Spatial Sense, Patterning and Algebra, and Data Management and Probability. Seven mathematical processes are also identified—problem solving, communicating, reasoning and proving, reflecting, representing, connecting, and selecting tools and computational strategies—that describe the practices students need to learn and apply in all areas of their mathematics studies. In Grades 1–12, students are actively engaged in applying these mathematical processes throughout their programs.

Problem solving is central to learning mathematics. By learning to solve problems and by learning through problem solving, students connect all other mathematical ideas and processes, and develop conceptual understanding. Problem solving allows students to use the knowledge they bring to school and helps them connect mathematics with situations outside the classroom. It gives meaning to skills and concepts in all strands. It also provides opportunities for students to reason, communicate ideas, make connections, and apply knowledge and skills, and it promotes collaboration and the sharing of ideas and strategies, and promotes discussion of mathematics.

In Grade 4 mathematics, students do the following in each of the five strands:

- Number Sense and Numeration—Work with whole numbers, decimal numbers, and simple fractions; understand magnitude; and solve problems and use proportional reasoning.
- Measurement—Use strategies to estimate, measure, and record length, perimeter, area, mass, and volume; and determine relationships among units and measurable attributes.
- Geometry and Spatial Sense—Learn about the geometric properties of quadrilaterals and three-dimensional figures, compare angles, construct three-dimensional figures, and identify and describe the location of an object.
- Patterning and Algebra—Learn about numeric and geometric patterns and predictions related to patterns and repeating patterns, and understand equality between pairs of numeric expressions.
- Data Management and Probability—Collect and display discrete data, interpret data, and make predictions related to a simple probability experiment, conduct an experiment, and compare the prediction to the results.

In Grade 8 mathematics, students do the following in each of the five strands:

- Number Sense and Numeration—Use equivalent representations for numbers, including positive exponents; solve problems using whole numbers, decimal numbers, fractions, and integers; and use proportional reasoning in meaningful contexts to solve problems.
- Measurement—Learn about applications of volume, relationships among units, and measurable attributes, including the area of a circle and volume of a cylinder.
- Geometry and Spatial Sense—Learn about the geometric properties of quadrilaterals and circles; develop relationships and solve problems involving lines, triangles, and polyhedra; and use the coordinate plane to represent transformations.

- Patterning and Algebra—Use graphs, algebraic expressions, and equations to represent linear growth patterns; model linear relationships, both graphically and algebraically; and solve and verify algebraic equations.
- Data Management and Probability—Collect and organize data, explore data relationships, and use probability models to make predictions about real-life events.

Science Curriculum in Primary and Lower Secondary Grades

The *Ontario Curriculum, Grades 1–8 Science and Technology* and *Le curriculum de l'Ontario–Sciences et technologie, 1re à 8e année* are consistent with Canada's goals of science education outlined in the *Common Framework of Science Learning Outcomes K–12*, which are intended to develop the scientific literacy of Canadian students.[8, 9, 10]

Ontario's elementary science and technology curriculum is structured around the relationships among fundamental concepts, big ideas, and the goals of science and technology to provide a framework for teaching overall and specific expectations. The French-language curriculum for science and technology is developed, implemented, and revised in parallel with the English-language curriculum and follows the aforementioned *Aménagement Linguistique* policy.[11]

Ontario's elementary science and technology curriculum has three goals: relate science and technology to society and the environment; develop the skills, strategies, and habits of mind required for scientific investigation and technological problem solving; and understand the basic concepts of science and technology. These three goals and their interrelationship within the curriculum expectations reinforce the notion that learning in science and technology cannot be viewed as merely learning facts. Rather, science and technology is a subject in which students learn, in age-appropriate ways, to consider both the knowledge and skills that will help them understand and critically consider the impact of developments in science and technology on modern society and the environment.

The science and technology curriculum expectations are organized into four strands: Understanding Life Systems, Understanding Structures and Mechanisms, Understanding Matter and Energy, and Understanding Earth and Space Systems. Through scientific investigation and technological problem solving, students engage in learning activities that allow them to develop knowledge and understanding of scientific and technological ideas in much the same way scientists would. Through inquiry, experimentation, and problem solving, students engage in exploration, experimentation, and investigations to develop their ability to design solutions to problems and to make connections to society and the environment.

In the Grade 4 science, students do the following in the four science strands:

- Understanding Life Systems—Learn about habitats and communities, human impacts on habitats, and the relationships among humans, plants, and animals in these communities.
- Understanding Matter and Energy—Learn about the properties of light and sound as forms of energy and their interactions with the environment, and examine technologies which use sound and light and their impact on daily life and on society.
- Understanding Structures and Mechanisms—Learn about pulleys and gears and broaden understanding of simple machines; and learn that pulleys and gears can transfer motion from one object to another, change the speed and direction of an object's motion, and change the amount of force needed to move an object.
- Understanding Earth and Space Systems—Study rocks and minerals as an introduction to the science of geology; and examine different types of rocks and minerals, and learn that their unique properties and characteristics are the result of the process of their formation.

In the Grade 8 science, students do the following in the four science strands:

- Understanding Life Systems—Develop knowledge of organisms, focusing on the structure and function of plant and animal cells; use microscopes; and examine cells, the basic units of life, to broaden understanding of living things.
- Understanding Matter and Energy—Learn about properties of fluids as a basis for understanding hydraulics and pneumatics; and investigate the concepts of fluid viscosity and density, and begin to understand the diverse applications of these properties in fluid mechanics.
- Understanding Structures and Mechanisms—Become familiar with the fundamental concepts of systems in the natural, mechanical, and human

worlds; and learn to calculate mechanical advantage, overall efficiency, and effectiveness of various systems and assess the personal, social, and environmental impacts of various systems.

- Understanding Earth and Space Systems—Study water, a crucial resource to life on Earth that must be managed sustainably; and develop an understanding of Earth's water systems and explore the individual's role in preserving this precious resource.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Materials, Equipment, and Laboratories

The Ministry of Education evaluates, approves, and provides, textbooks for teacher and student use in Ontario classrooms. Textbooks approved by the ministry must support at least 85 percent of the curriculum expectations for the subject area. All textbooks that meet ministry requirements are placed on a central list from which schools and school boards select textbooks that meet their local needs.

The Ministry of Education does not prescribe compulsory laboratory materials, equipment, or time allocations for science education. In mathematics, the appropriate use of manipulatives is strongly encouraged.

Use of Technology

In Ontario, there is an increasing emphasis on integrating technology as a part of the teaching and learning process.

Information and communications technologies (ICT) provide a range of tools that can significantly extend and enrich teachers' instructional strategies and support student learning in mathematics and in science and technology. Mathematics instruction is encouraged to incorporate different technologies, including interactive whiteboards, graphing calculators, ministry-licensed computer software, and laptop and netbook computers. The ministry has developed and tested the effectiveness of some interactive web-based lesson sequences on hard-to-teach and hard-to-learn topics, such as fractions and integers. Some pilot projects involve mobile devices such as tablets and smartphones. As in mathematics, science and technology instruction is encouraged to incorporate different technologies, including graphing calculators, scientific probeware, and ministry-licensed computer software.

The Ontario Ministry of Education supports online learning as well as blended learning, which combine online learning and face-to-face instruction. Ontario also has a Homework Help program, which provides online tutoring in mathematics for students in Grade 7–10.[12]

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

In Ontario, teachers of students in Grades 1–6 are not required to be subject specialists in mathematics or science. Teachers of students in Grades 7–10 are prepared to teach all subjects but also may be qualified as mathematics or science specialists. To teach mathematics or science in Grades 11 and 12, teachers must have a specialist qualification in their respective subject. All teachers can teach mathematics and science by mutual agreement with the school principal without holding the qualification.

Homework Policies

There is no official provincial policy on homework. District school boards develop and implement homework policies at the local level.

Teachers and Teacher Education

To teach in the publicly funded primary school system, a teacher must be a member of the Ontario College of Teachers. To become a member of the College, a teacher must have completed a minimum three-year postsecondary academic degree from an acceptable postsecondary institution and a one-year teacher education program consisting of coursework in education foundations, curriculum, and instruction, and at least eight weeks of practice teaching. Teachers can complete teacher education programs consecutively after their academic degree, or concurrently with their academic degree.

In Ontario, teacher education programs lead to certification in two divisions of the school system—Primary and Junior divisions (kindergarten–Grade 6), Junior and Intermediate divisions (Grades 4–10), Intermediate and Senior divisions (Grades 7–12)—or in Technological Education (Grades 9–12).

Requirements for Ongoing Professional Development

Providing for ongoing professional learning is a responsibility shared by the Ministry of Education, the Ontario College of Teachers, teachers' federations, and Ontario school boards. The ministry mandates two Professional Activity (PA) days for schools and school boards to work on provincial education priorities, and up to four more PA days for other professional development activities. The ministry also supports professional learning at all stages of a teacher's career (e.g., New Teacher Induction Program, a growth-oriented teacher performance appraisal process, and the Teacher Learning and Leadership Program, which provides funding for advanced, self-directed learning).

In mathematics, the ministry's Student Achievement Division supports job-embedded professional education to improve student learning and achievement, using effective evidence-based practices (e.g., Collaborative Inquiry in Learning Mathematics, differentiated instruction, and scheduled time blocks for mathematics). The ministry conducts and commissions research and supports professional learning in mathematics through symposia, webinars and teleconferences, summer programs, and the production of print and multi-media resources.

Monitoring Student Progress in Mathematics and Science

In Ontario, teachers are responsible for classroom assessment and evaluation to improve student learning. Teachers and early childhood educators bring varied assessment and evaluation approaches to the classroom, including assessment "for, as, and of" learning. The Ministry's curriculum policy documents include an achievement chart that identifies four categories of knowledge and skills: knowledge and understanding, thinking and inquiry, application, and communication. The achievement chart is a standard province-wide guide used by teachers to make judgments about student work that are based on clear performance standards and on a body of evidence collected over time.[13]

The Education Quality and Accountability Office, an agency within the Ministry of Education, develops and administers annual large-scale provincial assessments. Assessments are administered in English or French to all students in Grades 3 and 6 (reading, writing, and mathematics), Grade 9 (mathematics), and Grade 10, which is when the Ontario Secondary School Literacy Test (OSSLT) is first administered. Results do not affect student grades or promotion in Grades 3, 6, and 9. Ninth grade teachers have the option of scoring the Grade 9 mathematics tests and counting the result as a portion of the course grade. To obtain an Ontario Secondary School Diploma, all students must meet a graduation literacy requirement by passing the OSSLT. Students who are not successful on this test may retake it or meet the requirement by passing the Ontario Secondary School Literacy Course.

The Grade 3, 6, and 9 assessments are based on Ontario curriculum expectations and the OSSLT is based on the cross-curricular reading and writing expectations up to the end of Grade 9. All assessments include both selected-response and open-response questions, and all writing assessments include extended writing. (More information on provincial assessments may be found at the Education Quality and Accountability Office's website.)[14]

Impact and Use of TIMSS

Ontario benefits from participating in national and international assessments, which provide external measures of student achievement, in addition to the provincial assessment program run by the Education Quality and Accountability Office. These assessments also contribute to Ontario's overall education strategy to raise the bar, close gaps in student achievement, and increase confidence in public education.

TIMSS results, along with other evidence, inform Ministry of Education decisions on curriculum implementation supports and professional learning in mathematics for teachers and administrators. The ministry also sponsors research on specific topics, strategies, and resource use in mathematics. This research, along with other data from teachers, schools, and school boards, is used to identify and target the development of resources as well as focus professional learning sessions. Because there is no provincial testing in science and technology at Grade 4, TIMSS results provide the only measures of student achievement at this level. TIMSS results, along with results from the national Pan-Canadian Assessment Program (PCAP), provide external measures of student achievement in Grade 8 science and technology.

Suggested Readings

For more information in both English and French about Ontario's policies, programs and initiatives, consult the Ontario Ministry of Education's website: http://www.edu.gov.on.ca

Resources for system leaders, facilitators, teachers, and students to assist teaching and learning in mathematics may be found on the Math GAINS website: http://www.edugains.ca/newsite/math2/index.html

More information about provincial large-scale assessments may be found on EQAO's website: http://www.eqao.com

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Province of Québec

Hélène Paradis
Denis Besner
Ministère de l'Éducation, du Loisir et du Sport (MELS)

Introduction

Overview of the Education System

In Québec, the education system offers a variety of free educational programs and services to the public, from preprimary through university, including vocational training. The Department of Education, Recreation and Sports (*Ministère de l'Éducation, du Loisir et du Sport*, or MELS) fulfills different functions at the various levels of education. MELS develops programs and determines objectives and, often, content or standards for preprimary through university education. MELS negotiates labor relations, signs collective agreements, defines a normative framework, and provides most educational resources. At the university level, MELS promotes the advancement of teaching and research by providing universities with resources for operation and development while respecting their autonomy and fostering collaboration among various partners.

The Québec Education Program (QEP) for preprimary, primary, and secondary education is based on the development of competencies, including cross-curricular competencies—broad areas of learning that address major issues confronting young people, and programs of study grouped into various subject areas. The QEP defines a competency as "a set of behaviors based on the effective mobilization and use of a range of resources."[1] One of the aims of the educational program is ensuring that knowledge serves as a tool for both acting and thinking; because competencies are complex and develop over time, students can use their knowledge to increase their mastery of a competency throughout schooling and beyond. The QEP also produces complementary documents to provide additional information on the knowledge that students must acquire and be able to use in each year of primary and secondary school.

Preprimary education in Quebec is for five-year-olds and is full-time; it is not compulsory, but nearly all children are enrolled. Children with disabilities or those from disadvantaged backgrounds may be admitted to preprimary education starting at age four. Primary education (Grades 1–6) is compulsory and comprises three 2-year learning cycles: Elementary Cycle One, Two, and Three. Secondary education consists of five years of studies divided into two cycles: Secondary Cycle One lasts two years (Grades 7–8) and, for all students, is a continuation of the common core education begun in primary school; Secondary Cycle Two lasts three years (Grades 9–11). School attendance is compulsory until the year in which students turn 16 years of age, which normally corresponds to Grade 10 (Secondary 4).

Seventy-two linguistic school boards in Québec administer the public school system: 60 are French, nine are English, and three have a special status (two of these provide services primarily to Aboriginal students). Private institutions, most of which are subsidized by MELS, also provide primary and secondary education. These institutions are subject to the same regulations as public institutions and must implement the official curriculum. The private school system accounts for 7 percent of primary students and 20 percent of secondary students in the youth sector.

The Preschool and Elementary Education Program has been in effect in Québec schools since September 2000, and in the Secondary Cycle One program since September 2005.[2, 3] The new curricula were introduced gradually—in September 2000 for Grades 1–2, in September 2001 for Grades 3–4, and in September 2003 for Grades 5–6. In secondary education, the new curricula were introduced in September 2005 for Grade 7 (Secondary 1) and in September 2006 for Grade 8 (Secondary 2). The Secondary Cycle Two program also was implemented gradually from September 2007 to September 2009.[4]

Languages of Instruction

In Québec, French is the official language and the language of instruction. Approximately 80 percent of the total population of Québec is French-speaking. The English-speaking population, which accounts for about 9 percent of the total, has access to a full network of English educational institutions, from preschool to university. There are eleven Aboriginal nations in Québec: eight are under federal jurisdiction, while the other three are the responsibility of the provincial government under the aegis of MELS. Aboriginal students are taught in their mother tongue for the first four years of elementary school. Increased immigration has resulted in the arrival of large numbers of students whose first language is neither French nor English, especially in the greater Montréal area. These students attend French-language schools and schools offer francization services and welcoming classes to meet their particular needs.

Mathematics Curriculum in Primary and Lower Secondary Grades

Mathematics is a compulsory subject in Québec throughout elementary and secondary school.[5, 6] The mathematics programs consists of compulsory concepts and processes, and concepts are grouped together by cycle in the three Elementary Cycles (Grades 1–6) and in Secondary Cycle One (Grades 7–8), and by year for each of the three years of Secondary Cycle Two (Grades 9–11). Three program of study options are available to students in Grades 10 and 11 (Secondary 4 and 5): the Cultural, Social, and Technical option; the Technical and Scientific option; and the Science option. Students who wish to pursue study in the Science option or in certain technical training programs in college (i.e., the 12th and 13th years of study) must successfully complete the appropriate option.

Though studying mathematics, students develop skills in interpreting reality and predicting, generalizing, and making decisions in a changing world. Learning mathematics enables students to do the following:

- Use mathematical reasoning to make conjectures and to criticize, justify, or refute a proposition by drawing on an organized body of mathematical knowledge;
- Communicate (interpret, produce, and convey) messages in contexts in which the object of the message, the purpose of the communication, and the target audience play a significant role; and
- Solve situational problems by using various strategies for understanding, organizing, solving, validating, and communicating.

Exhibit 1 presents the mathematics program concepts that Québec students should have successfully mastered by the end of Elementary Cycle Two (Grade 4).

Exhibit 1: Mathematics Concepts Covered by End of Elementary Cycle Two (Grade 4)

Content Area	Main Topics	Concepts
Arithmetic	Understanding and Writing Numbers	Natural numbers less than 100,000—Reading, writing, counting, enumerating, various representations, comparisons of numbers, classification, ordering numbers, equivalent expressions, decomposition, patterns, properties (even and odd numbers), squares and prime and composite numbers, number line, and approximation;
		Fractions based on a whole or a collection of objects—Reading; writing; numerator; denominator; various representations (using objects or pictures); equivalent parts; congruent parts; and comparison with 0, ½, and 1; and
		Decimals up to hundredths—Reading, writing, various representations, ordering decimals, equivalent expressions, decomposition, number line (between two consecutive natural numbers), and approximation.
	Meaning of Operations	Natural numbers and decimals— Choice of operation and operation sense (e.g., addition, subtraction, multiplication, and division); meaning of an equality relation, meaning of an equivalence relation; relationships between operations (addition and subtraction); properties of operations: commutative, associative; multiples of a natural number; and set of factors of a natural number.
	Operations Involving Numbers	Natural numbers—Approximation of the result (addition and subtraction); mental computation (own processes) (addition and subtraction); operations to be memorized (addition and subtraction); written computation (adding two four-digit numbers; subtracting a four-digit number from a four-digit number such that the difference is greater than 0); written computation (multiplying a three-digit number by a one-digit number; dividing a three-digit number by a one-digit number); and patterns; and
		Decimals—Written computation (e.g., addition and subtraction whose result does not go beyond the second decimal place).
Geometry	Space	Locating objects on an axis, locating objects in a Cartesian plane.
	Solids	Comparing, constructing, and identifying solids (spheres, cones, cubes, cylinders, prisms, and pyramids); describing prisms and pyramids (faces, vertices, edges); and classifying and constructing prisms and pyramids.
	Plane Figures	Comparing, identifying, and describing plane figures (square, rectangle, triangle, rhombus, trapezoid, parallelogram, circle); describing convex and non-convex polygons; describing and classifying quadrilaterals (parallel segments, perpendicular segments, right angles, acute angles, obtuse angles, congruent sides); and identifying and constructing parallel lines and perpendicular lines.
	Frieze Patterns and Tessellations	Identifying congruent figures; observing and producing patterns using geometric figures; and observing and producing frieze patterns and tessellations by means of reflections.
Measurement	Lengths	Estimating and measuring (conventional units: m, dm, cm, and mm); relationships between units of measure (m, dm, cm, and mm); and calculating the perimeter.
	Surface Areas	Estimating and measuring surface areas (unconventional units).
	Volumes	Estimating and measuring volumes (unconventional units).
	Angles	Comparing angles: right, acute, and obtuse.
	Time	Estimating and measuring time and duration (conventional units: day, hour, minute, second, daily cycle, weekly cycle, yearly cycle).
Probability and Statistics		Interpreting and displaying data (e.g., table, bar graph, pictograph, and line graph); and
		Enumerating the possible outcomes of a simple random experiment.

Exhibit 2 presents the mathematics program concepts and processes that Québec students should have successfully mastered by the end of Secondary Cycle One (Grade 8).

Exhibit 2: Mathematics Concepts and Processes Covered by End of Secondary Cycle One (Grade 8)

Content Area	Main Topics	Concepts
Arithmetic	Number Sense with Regard to Decimal and Fractional Notation and Operation Sense	Reading, writing, various representations, patterns, and properties—Order of magnitude, comparison of numbers; and decomposition of numbers (e.g., additive, multiplicative);
		Fractional, decimal and exponential (integral exponent) notation; and percentage, and square root—Identifying different meanings of fractions (part of a whole, division, ratio, operator, measurement); switching from one way of writing numbers to another; and simplifying and reducing fractions;
		Approximation (estimating, rounding off, truncating);
		Properties of divisibility (by 2, 3, 4, 5, and 10)—Use in different contexts;
		Rules of signs for numbers written in decimal notation;
		Equality relation: meaning, and properties and rules for transforming numerical equalities (balancing equalities)—Transforming arithmetic equalities;
		Operations and inverse operations: addition and subtraction, multiplication and division, and square and square root—Translating a situation using an operation; mental computation; and written computation;
		Properties of operations— Commutative and associative properties, distributive property of multiplication over addition, or subtraction and factoring out the common factor; and simplifying terms of an operation;
		Order of operations: use of no more than two levels of parentheses in different contexts; and
		Location on an axis or in a Cartesian plane
	Understanding Proportionality	Ratio and rate—Ratios and equivalent rates, unit rate, comparison of ratios and rates, and translating a situation using a ratio or rate;
		Proportion—Equality of ratios and rates, ratios and coefficients of proportionality; and recognizing and solving proportional problems;
		Percentage—Finding a specified percentage of a number and values corresponding to 100 percent; and
		Variation—Direct and inverse.
Algebra	Understanding Algebraic Expressions	Algebraic expression—Variable, coefficient, degree, term, and like terms; constructing and interpreting algebraic expressions; finding equivalent algebraic expressions; and numerical evaluation of algebraic expressions;
		Operations on algebraic expressions—Addition, subtraction, multiplication of first-degree monomials, and division by a constant;
		Equality, equation, and unknowns; and
		First-degree equations in one unknown expressed in the form $ax + b = cx + d$.
	Understanding Dependency Relationships	Analysis of situations using different types of representation (e.g., graph, table of values, and words); and
		Overall representation of a situation by a graph.

Content Area	Main Topics	Concepts
Geometry	Plane Figures	Triangles, quadrilaterals, and regular convex polygons—Segments and lines (e.g., bisector, perpendicular bisector, median, altitude, base, and height); Circle and sector—Radius, diameter, chord, arc, and central angle; and Measurement—Degree (angle and arc); length; perimeter, circumference; area, lateral area, surface area; choice of units of measure for lengths and areas; relationships between SI units of length and SI units of area.
	Angles	Complementary, supplementary; angles formed by two intersecting lines (e.g., vertically opposite, and adjacent); angles formed by a transversal intersecting two other lines (e.g., alternate interior, alternate exterior, and corresponding).
	Solids	Right prisms, right pyramids, and right cylinders; possible nets of a solid; and decomposable solids.
	Congruent and Similar Figures	Translation, reflection, rotation, and dilation.
Probability and Statistics	Random Experiment	Random experiments involving one or more steps (with or without replacement and with or without order); outcome of a random experiment; enumerating possibilities using charts, network diagrams, tree diagrams, and Venn diagrams; and sample space.
	Event	Certain, probable, and impossible events; simple, complementary, compatible, incompatible, dependent, independent events; and calculating the probability of an event.
	Types of Probability	Theoretical probability and experimental probability.
	Population, Sample	Survey, poll, census; representative sample; sampling methods (e.g., simple random and systematic); and sources of bias.
	Data	Gathering data; qualitative variable; discrete or continuous quantitative variable; comparing distributions; and minimum, maximum, arithmetic mean, and range.
	Tables	Characteristics, population, and frequencies.
	Reading Graphs	Bar graph, line graph; and pie chart.

Science Curriculum in Primary and Lower Secondary Grades

In Elementary Cycle One (Grades 1–2), science and technology is taught as part of other subjects. In Elementary Cycles Two and Three (Grades 3–6), the basic school regulation indicates that science and technology is compulsory, but the time allotted for instruction is not prescribed. In Secondary Cycle One (Grades 7–8), the instructional time guideline is 100 hours per year.[7] Science and Technology is a compulsory subject in the third and fourth years of Secondary Cycle Two (Grades 9–10).[8, 9] For the third year of Secondary Cycle Two (Grade 11, Secondary 5), science and technology programs are optional. Students who wish to pursue their studies in the Science option or in certain technical training programs in college must successfully complete Grade 11 (Secondary 5) physics and chemistry.

Learning science and technology in primary school enables students to:

- Propose explanations for or solutions to scientific or technological problems;
- Make the most of their knowledge of science and technology; and
- Communicate in the languages of science and technology.

Teachers are free to choose themes from those listed in the program, and complementary documents provide additional information on the areas that should be emphasized. Exhibit 3 presents the science and technology program concepts and skills that Québec students should have successfully mastered by the end of Elementary Cycle Two (Grade 4).

Exhibit 3: Science and Technology Concepts and Skills Covered by End of Elementary Cycle Two (Grade 4)

Content Area	Topics
The Material World	Properties and characteristics of matter; physical changes; forms and sources of energy; transmission and transformation of energy; motion; effects of a force; and simple machines and mechanisms.
The Earth and Space	Properties and characteristics of soil; the water cycle and precipitation; forms and sources of energy; and the sun–Earth–moon system (rotation, revolution, lunar cycle, and eclipses).
Living Things	Characteristics, needs, organization, and transformation of living things; sources of energy for living things; animal locomotion; and ecology (habitats, populations, interaction between living organisms, and adaptations).
Techniques	Use of simple measurement instruments; and the design and manufacture of instruments, structures, mechanisms, and environments.
Language	Use of terminology specific to science and technology; and types of representations specific to science.

Exhibit 4 presents the science and technology program concepts and skills that Québec students should have successfully mastered by the end of Secondary Cycle One (Grade 8).

Exhibit 4: Science and Technology Concepts and Skills Covered by End of Secondary Cycle One (Grade 8)

Content Area	Main Topics	Sub-topics
The Living World	Diversity of Life Forms	Habitat; ecological niche; species; population; physical and behavioral adaptations; similarities and differences among various species; taxonomy; transmission of hereditary traits from generation to generation through genes; and use of techniques for designing and manufacturing environments.
	Survival of Species	Asexual and sexual reproduction; reproductive mechanisms in plants and animals; contraception; methods of preventing the implantation of the zygote in the uterus; and sexually transmitted and blood-borne diseases.
	Life-sustaining Processes	Characteristics of living things; plant and animal cells; photosynthesis and respiration; cellular components visible under a microscope; inputs and outputs (energy, nutrients, and waste); and osmosis and diffusion.
The Material World	Properties	Characteristic properties of matter; concepts of mass, volume, and temperature; changes in the state of matter (solid, liquid, and gas); and acidity and alkalinity.
	Changes	Physical and chemical changes; conservation of matter (conservation of the number of atoms); mixtures; solutions; and separation of mixtures.
	Organization	Difference between an atom and a molecule; elements; and the periodic table.
The Earth and Space	General Characteristics of the Earth	Internal structure of the Earth; hydrosphere, lithosphere, and atmosphere; types of rocks (basic minerals); types of soil; relief maps; atmospheric layers; distribution of water; and composition of the air.
	Geological and Geophysical Phenomena	Plate tectonics; volcanoes; earthquakes; orogenesis; erosion; natural energy resources (renewable and nonrenewable); wind; and the water cycle.
	Astronomical Phenomena	Gravity; the solar system; properties of light; cycles of day and night; phases of the moon; eclipses; seasons; comets; aurora borealis; and meteor impacts.
The Technological World	Engineering	Specifications; design plans and technical drawings; manufacturing processes and techniques; materials (raw and manufactured); equipment; drafting techniques; and scales.
	Technological Systems	Systems (overall function, inputs, processes, outputs, and control); basic mechanical functions (links and guiding control); and transformation of energy.
	Forces and Motion	Types of motion; effects of a force; simple machines; and motion transmission and transformation mechanisms.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Materials, Equipment, and Laboratories

Teachers must use MELS-approved instructional materials. However, teachers are not limited to a single pedagogical approach or instructional resource; they are free to choose their own learning situations, pedagogical approaches, problems, and resources and to determine how students will use these resources. MELS provides funding to update necessary laboratories and workshops to help students develop competencies in science and technology.

Use of Technology

The primary and secondary Québec Education Program provides for the use of information and communications technologies (ICT). For over a decade, MELS has been working to set up a directory of teaching resources, including the following examples:

- *Carrefour-Éducation*, which primarily lists websites and theme-based guides; [10]
- A software directory (*Logiciels éducatifs*), which provides a brief summary of easily accessible interactive resources; [11]
- A collection of educational videos (*La collection de vidéos éducatives*), which meet the requirements of the Québec Education Program; [12] and
- *Livre Ouvert*, a selection of quality books for students in preschool, primary, and secondary education.[13]

Other initiatives exist, but these are the most commonly used. The ministry also subsidizes schools' technology resources.

In February 2011, the Premier of Québec announced an action plan for the use of ICT, School 2.0: Connected Classrooms.[14] The action plan will promote access to and use of digital technology in schools by providing for an interactive white board and multimedia projector for each classroom, as well as a laptop computer for each teacher.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Students start having subject specialists for most of their courses in the first year of secondary school (Grade 7).

Homework Policies

MELS does not have an official homework policy, but it offers homework assistance to Québec students in two ways: the Homework Assistance Program in Elementary School, and *Allô Prof.*[15] The purpose of the Homework Assistance Program in Elementary School is to improve student learning and academic success by offering students help with homework and studying. As part of the program, schools must implement various support measures to ensure the availability of their services and homework assistance. *Allô Prof* is a not-for-profit organization that supports student learning by providing homework assistance free of charge to children and parents in Québec. It has set up a telephone help-line and online services with a team of qualified teachers and a virtual community made up of student peers, parents, and educators. Since its launch, *Allô Prof* has answered more than 1.8 million queries from students and parents.

Teachers and Teacher Education

A four-year bachelor's program in preprimary and primary education is required to teach preprimary and primary school (Grades 1–6). The program trains generalists to teach all subjects other than those requiring specialists, such as music, physical education and health, and second languages. In secondary school, teachers must hold a bachelor's degree in secondary education, preferably with a specialization in their subject area.

Requirements for Ongoing Professional Development

The most common forms of professional development for teachers are university studies, training provided by MELS or the school boards, and conferences. Teachers increasingly appreciate peer-led continuing education and collaboration in action research projects.

Monitoring Student Progress in Mathematics and Science

At the end of primary school, MELS administers compulsory examinations in mathematics. Teachers score the examinations using a scoring guide. The ministry sometimes collects samples of student work in order to better understand student learning in this subject.

To earn a diploma, students must pass standard examinations (Provincial Diploma Examinations, or DIPS) in mathematics and science and technology (i.e., Science and Technology or Applied Science and Technology) at the end of Grade 10 (Secondary 4). The ministry scores the multiple-choice section of these examinations and schools score the constructed-response items using ministry-sponsored scoring guides. Schools are responsible for student evaluation, and must adopt a local evaluation policy compliant with current ministerial frameworks.

Impact and Use of TIMSS

In the last two decades, a number of briefs, reports, and studies produced primarily by UNESCO, OECD, and the International Association for the Evaluation of Educational Achievement (IEA) have spurred reflection on how to adapt schools to new social and cultural realities. The Québec Education

Program reflects on these analyses and choices as part of a collective educational project in which more than 500 people have participated, including teachers, school administrators, consultants, and other professionals working in education and in universities. TIMSS results in particular are used in establishing program orientations in order to better prepare young people for the twenty-first century and to help them remain competitive on the world stage.

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Emirate of Abu Dhabi

P-12 Policy Sector
Abu Dhabi Education Council

Introduction

Overview of the Education System

The Abu Dhabi Education Council (ADEC) is responsible for all educational decisions in the Emirate of Abu Dhabi. ADEC operates 302 public schools and regulates 176 private schools offering Kindergarten to Grade 12.[1] There are 127,000 students in public schools and 180,000 in private schools in Abu Dhabi.[2] Public schools have a population that is 74 percent Emirati nationals and 26 percent expatriate.[3] Private schools have a population that is approximately 76 percent expatriate and 24 percent Emirati nationals.[4] Several private schools offer international curricula including the International Baccalaureate, Advanced Placement Courses, and General Certificate of Secondary Education, as well as Asian programs.

The public schools operate in a centralized system with centrally developed policies, curricula, and common year-end assessments. Performance standards are established by ADEC.

Since 2007, ADEC has operated an increasing number of schools in a public-private partnership. Private operators are contracted to place advisory staff in public schools. These advisors provide advice and support to administrators and teachers concerning the implementation of curriculum and changes in pedagogy.

An emphasis on science, mathematics, and technology is outlined in the *Abu Dhabi Vision 2030* and the *Abu Dhabi Education Council 10 Year Strategic Plan 2009–2018*.[5, 6] As a result of the *Abu Dhabi Vision 2030*, many government departments have signed memoranda of understanding with ADEC, which include an emphasis on developing career paths and post-secondary opportunities in mathematics, science, and technology.

Languages of Instruction

The language of instruction in Abu Dhabi schools is either Arabic or English, although Arabic is the official language of the Emirate and the most common mother tongue in public schools. Arabic was the language of instruction for all subjects in public schools until 2007, when ADEC began introducing English resources and bilingual instruction in mathematics and science in some schools. While some of the Grade 4 students assessed in TIMSS 2011 would have been in bilingual classrooms, those students in Grade 8 would have received instruction in Arabic with only some English resources present. All students in public schools were assessed in Arabic in TIMSS 2011.

Either Arabic or English is the language of instruction in private schools. TIMSS 2011 students in private schools were assessed in the declared language of instruction. For those schools tested in English, English was the second language of the majority of students.

In 2010, significant language instruction reform termed the New Schools Model began in public schools (Kindergarten through Grade 3) where students currently receive bilingual instruction.[7] English language, mathematics, and science are taught through an integrated English literacy program using similar pedagogy and resources to those used by the Arabic literacy program.[8] Full implementation of the New School Model will be achieved in all grades by 2016.

Mathematics Curriculum in Primary and Lower Secondary Grades

Standards form the basis for the desired learning outcomes in public schools. The standards in Abu Dhabi's *K–5 Mathematics and Science Curriculum* describe the mathematics knowledge, skills, and understanding that each student should achieve at each grade, from Kindergarten to Grade 5 (Year 5).[9] Similarly, the standards in the *6–9 Mathematics Curriculum* describe the knowledge, skills, and understanding that each student should achieve at each grade, from Grades 6–9.[10] Private schools have a variety of curricula based on the school's own curriculum standards, including American, Arabic, Australian, British, Canadian, German, and Japanese schools.

Based on public school standards in Abu Dhabi, Grade 5 students should be able to do the following:

- Use appropriate terminology to describe and link mathematical ideas, check statements for accuracy, and explain reasoning;
- Count, order, read, and write numbers up to 9,999 and solve addition and subtraction problems involving numbers of up to 4 digits, and multiply and divide two-digit numbers by one-digit numbers;
- Compare and represent simple fractions, decimals, and percentages;

- Perform simple calculations with money and conduct simple probability experiments;
- Generate, describe, and write number patterns, and understand relationships between multiplication and division operations up to 10x10;
- Estimate, measure, compare, and record length, area, volume, capacity, and mass, using formal units;
- Read and record time, and make comparisons between time units;
- Gather, organize, and interpret data;
- Label, describe, and draw three-dimensional objects and two-dimensional shapes; and
- Use coordinates to describe position and compass points to give and follow directions.

Grade 8 students should be able to do the following:

- Explain and verify mathematical relationships, and link mathematical ideas to existing knowledge and understanding;
- Use mathematical language and notation to explain mathematical ideas, and interpret tables, diagrams, and text in mathematical situations;
- Apply knowledge of ratio and rates to problems;
- Use scientific notation to simplify and evaluate arithmetic expressions;
- Express recurring decimals as fractions, and round numbers to a specified number of significant figures;
- Determine relative frequencies and theoretical probabilities;
- Solve simple inequalities;
- Develop tables of values from simple relationships, illustrate these relationships on the Cartesian plane, and graph and interpret simple linear relationships;
- Solve simultaneous linear equations graphically;
- Use the laws of exponents to simplify algebraic expressions;
- Find the area and perimeter of polygons, circles, and composite figures;
- Find the surface area and volume of prisms and cylinders;
- Use a range of strategies when analyzing data; and

- Use reasoning to solve numerical problems from geometry, drawing on knowledge of the properties of similar and congruent triangles, the angle properties of polygons, and the properties of quadrilaterals.

Science Curriculum in Primary and Lower Secondary Grades

The standards in the public school *K–5 Mathematics and Science Curriculum* describe the knowledge, skills and understandings that each student should achieve at each grade, from Kindergarten to Grade 5 (Year 5).[11] Similarly, the standards in the *6–9 Science Curriculum* describe the knowledge, skills, and understanding that each student should achieve at each grade, from Grades 6–9.[12] Private schools have a variety of curricula.

Based on public school standards in Abu Dhabi, Grade 5 students should be able to do the following:

- Independently conduct the steps of a scientific investigation, such as observing, questioning, predicting, testing, and recording accurate results, analyzing data and information, and drawing conclusions;
- Select and safely use equipment;
- Identify and describe the structures and functions of living things and how they interact with each other and their environment;
- Identify forms and sources of energy, and ways in which energy causes change;
- Identify characteristics of the solar system, and describe interactions that affect conditions on Earth;
- Describe how the properties of materials affect their use;
- Identify the ways in which man-made environments, products, and services are constructed or produced; and
- Investigate the properties and uses of natural and man-made materials.

Grade 8 students should be able to do the following:

- Use scientific models to explain the arrangement of elements in the Periodic Table and the formation of compounds;
- Construct models of atoms, molecules, and compounds in order to understand the reorganization of atoms in chemical reactions;
- Have an understanding of pH and some common uses of acids and bases;

- Investigate the properties of different forms of radiation in the electromagnetic spectrum, and examine applications of radiation in medicine, industry, and communication;
- Construct electrical circuits to determine the relationship between voltage, resistance, and current, and use Ohm's Law to solve problems;
- Describe the importance of mitosis and meiosis to living things, and research forms of asexual and sexual reproduction;
- Examine the causes of infectious and non-infectious diseases and how vaccination programs control some diseases;
- Describe the functions of the nervous and endocrine systems and their coordination in the body;
- Investigate fossils and natural geologic events;
- Describe the process of fossilization and how rock strata provide information about the Earth's geologic past, locate earthquake and volcanic activity across the globe, and discuss ways to minimize the effects of natural disasters;
- Use cause-and-effect relationships to explain ideas, predict outcomes, and generate plausible explanations related to data; and
- Identify potential hazards when conducting scientific investigations, and justify conclusions.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Materials, Equipment, and Laboratories

In public schools, students in all mathematics courses receive a textbook and an exercise book, which have been written to specifically address the desired learning outcomes for each grade. Science students in Grade 4 have a science textbook and Grade 8 students receive a textbook and an activity book. The Abu Dhabi Education Council approves resources used by private schools, though these vary widely and depend on each private school's curriculum.

All public schools have science rooms for fourth grade students and laboratories for eighth grade students. These facilities are equipped and supplied centrally to provide all students access to science activities. Resources and facilities in private schools vary enormously from state-of-the-art science facilities to schools without equipment, supplies, or space.

Use of Technology

The technology infrastructure in Abu Dhabi public schools is currently being developed. As a result, some public and private schools have state-of-the-art facilities, while other schools do not yet have IT infrastructure, and therefore have limited facilities. All public school students have access to mind mapping (graphical idea organization), word processing, and presentation software. Private schools have a variety of technology available to their students.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

In public schools, fourth-grade students have specialist teachers in mathematics and science. Students will often have the same teacher for these subjects. In eighth grade, teachers are specialized in either mathematics or science. Private schools often have general education teachers in fourth grade, but almost all have specialized teachers in eighth grade classes.

Teachers and Teacher Education

For teachers in public schools, teacher education in Abu Dhabi follows the national model provided by the UAE Ministry of Education. Most teachers receive their education through a university degree program.

Monitoring Student Progress in Mathematics and Science

Student progress in Abu Dhabi public schools is monitored with various internal and external instruments. Beginning in the third grade, every March all students take the External Measurement of Student Achievement—a standardized test developed externally by Pearson Education using standards set by ADEC.[13] Because the examination uses standardized scores on a continuous scale for all grades, results can be used to track individual student progress over a student's entire school career. The test measures performance in Arabic, English, mathematics, and science.

Impact and Use of TIMSS

TIMSS 2011 will provide the first international benchmark of mathematics and science performance for students in Abu Dhabi. It will also provide a basis for validating other assessments currently being used or planned, such as the External Measurement of Student Achievement. Specific item analysis will provide ADEC with valuable information concerning areas of strength and weakness within the current curriculum.

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Emirate of Dubai

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Knowledge and Human Development Authority

Introduction

Overview of the Education System

The Emirate of Dubai has a unique education landscape, offering a complete education system for boys and girls from Kindergarten through higher education, and provided free of charge for residents of Dubai through public schools, colleges, and universities. Education from primary to upper-middle school is universal and compulsory.

The UAE's Ministry of Education provides policies and regulations for both public and private schools, as well as services for public schools. For public schools, the ministry is solely responsible for designing school administration structure, staff recruitment and compensation, curriculum design and improvement, and the availability of resources.[1]

The Knowledge and Human Development Authority (KHDA), an independent educational board, was established to develop the knowledge and human resource sectors in the emirate. KHDA identifies and implements evidenced-based strategies that are tailored to Dubai. This authority regulates the private schools in Dubai in alliance with the general policy of the ministry. KHDA's goals are to raise the quality of education to the highest international standard, to ensure the continuous development of the education sector, and improve the quality and outcomes of education on all fronts and at all stages.[2]

In 2008, the Dubai Schools Inspection Bureau was launched to define and measure education quality in order to support the improvement of education in Dubai and inform improvement planning at the school and policy level. Since 2009, significant reform has taken place at the school level, including annual school inspections every year (2009–11). All three rounds of inspection have been driven by the same key questions about the academic achievement of students, the quality of education (particularly the teaching) that schools provide, and the effectiveness with which they are led and managed.[3]

The number of students in Dubai's public schools has increased over the past two years. Indeed, the overall enrollment of students in Dubai schools is continuing to expand, with a 5.7 percent increase in the number of students in school in 2011 compared to 2010. Dubai also has an extensive private education sector, accounting for approximately 85 percent of the student population (approximately 190,000 students in 148 schools).[4] More children in Dubai's private schools are in the lower grades than in upper grades.

Some key features of the educational landscape in Dubai include the following: [5, 6]

- A large, increasing proportion of expatriate students (77%);
- An increasing proportion of Emirati national students educated in private schools (currently 57%);
- Thirteen different curricula offered across the school system, including United Kingdom curricula (31% of students in private schools), Indian curricula (30% of students in private schools), and United States curricula (21% of students in private schools); and
- The world's highest number of branch universities.

Languages of Instruction

The national language in the UAE, and in Dubai, is Arabic. Standard Arabic is used for printed matter, as well as for official and formal purposes, although English and several Asian languages are used widely, particularly in commerce. Statistics from 2010 estimate the population of Dubai at 1,905,476, with a significant annual growth rate.[7] National Emirati citizens account for approximately 10 percent of the population, with the remainder originating from the rest of the Arab world, the Indian subcontinent, the Far East, Europe, and elsewhere. In public schools, mathematics and science are taught in Arabic, while in private schools these subjects are taught in the school's language of instruction, which is primarily English. The multi-cultural nature of Dubai means that, in some international schools, students will be taught in English, though more than 50 languages may be spoken by students.

The Dubai Curriculum in Primary and Lower Secondary Schools

Dubai public schools use the UAE national curriculum to teach mathematics and science. Private schools use different mathematics and science curricula based on the school's own curriculum standards. Mathematics curricula in private schools vary between a strong focus on mental calculations, data handling, and investigative skills to a focus on content knowledge and limited opportunities for real life application in meaningful contexts. Several private schools use curriculum standards to benchmark students' mathematical skills with their peers internationally.

Science curricula in many private schools focus on developing students' scientific understanding and knowledge through a practical approach. Nevertheless, scientific inquiry remains under-developed at the primary level in most private schools. Many private schools have implemented initiatives to improve the curriculum and increase independent investigative skills in mathematics and science education. However, more changes are needed to expand mathematics and science curricula in private schools to include more challenging material and better progression.

Mathematics Curriculum in Primary and Lower Secondary Grades

Due to the large proportion of students in Dubai attending private primary schools, as opposed to public schools, summaries of the most widely used private school mathematics curricula in Dubai are provided below:

- Curriculum for United Kingdom (UK) Schools—During Key Stage 2, which includes Grade 4, students learn to do the following: use number systems more confidently; move from counting reliably to calculating fluently with all four arithmetic number operations (addition, subtraction, multiplication, and division); try to tackle problems with mental methods before using other approaches; explore features of shapes and spaces and develop measuring skills in a range of contexts; discuss and present their methods and reasoning using mathematical language, diagrams, and charts; and use and apply mathematics throughout the program of study. A number of key concepts underpin the study of mathematics in UK schools from Grade 7 (Key Stage 3), which are designed to deepen and broaden students' knowledge, skills, and understanding: competence, creativity, applications and implications of mathematics, and critical understanding. Students also are required to master four key processes: representing, analyzing, interpreting and evaluating, and communicating and reflecting.[8]

- Curriculum for International Baccalaureate Schools—Students taking the TIMSS 2011 assessment are in the Primary Years Program (Grade 4) and Middle Years Program (Grade 8).[9, 10] In the Primary Years Program, mathematics is taught partly through an inter-disciplinary program with science, and partly as a discrete subject. At Grade 8, students study mathematics and, usually, a combined science course. Inquiry, problem solving, and the application of mathematics are strongly emphasized, as is the acquisition of mathematical knowledge.

- Curriculum for United States (US) Schools—Most US schools in Dubai adopt a set of curriculum standards for mathematics relevant to a specific state and adapt these to meet the needs of their students within the Dubai context. Often these standards define content expectations relating to concepts and skills, ranging from between 26 to 89 topics, at each grade level beginning at Kindergarten. Other schools provide descriptions of the most significant mathematical concepts and skills at each grade level and identify important connections to other topics. A few US curriculum schools in Dubai incorporate processes such as communication, reasoning, representation, connections, and, particularly, problem solving into the mathematics curriculum. Students in these schools benefit from a more connected, coherent body of mathematical knowledge and way of thinking.

- Curriculum for Indian Schools (Central Board of Secondary Education and Indian Certificate of Secondary Education)—In primary schools offering the Indian curriculum, mathematical facts are often taught through rote learning. This method is expected to effectively build a strong base for the formation of higher concepts. Developing rapid mental calculation skills is emphasized from an early age. From eighth grade, students follow a course structure that includes number, algebra, geometry, and statistics. Although eighth-grade courses include examples to give students an opportunity to practice mathematical knowledge and skills in context, the curriculum is currently being developed to promote more problem solving in real life contexts.[11, 12]

Science Curriculum in Primary and Lower Secondary Grades

Summaries of the most widely used science curricula in private schools in Dubai are as follows:

- Curriculum for United Kingdom Schools—In Grade 4 (Key Stage 2), students do the following: learn about a wide range of living things, materials, and phenomena; begin to make links between ideas and to explain things using simple models and themes; apply their knowledge and understanding of scientific ideas to familiar phenomena, everyday things, and personal health; conduct investigations working alone and with others; and begin to use a range of reference sources in their work. The study of science at the secondary level (Key Stage 3), which includes Grade 8, engages learners at many levels, linking direct practical experience with scientific ideas. Experimentation and modeling are used to develop and evaluate explanations, encouraging critical and creative thought. Students learn to question and discuss issues that may affect their own lives, the direction of society, and the future of the world.[13]

- Curriculum for International Baccalaureate Schools—Students taking the TIMSS assessment are in the Primary Years Program (Grade 4) and Middle Years Program (Grade 8). In the Primary Years Program, science is taught in an inter-disciplinary program with mathematics, not as a separate subject. Eighth grade students usually take a combined science and mathematics course. Inquiry, problem solving, and the application of science are strongly emphasized, as well as the acquisition of scientific knowledge. The International Baccalaureate program expects that students will have opportunities to act as scientists rather than learn about science. As a consequence, students might be less familiar with a large body of factual content knowledge, but skilled in the process of scientific inquiry.

- Curriculum for United States Schools—Similar to the mathematics context, most US schools in Dubai adopt a set of curriculum standards for science relevant to a specific state and adapt these to meet the needs of their students.

- Curriculum for Indian Schools (Central Board of Secondary Education and Indian Certificate of Secondary Education)—Science plays an important role and is seen as developing students' cognitive, affective, and psychomotor abilities. Emphasis is placed on cultivating a spirit of inquiry, creativity, objectivity, and aesthetic sensibility. In the upper-primary stage, students engage with the processes of science to develop such skills as observing, recording, drawing, tabulating, plotting graphs, etc. By Grade 8, abstraction and quantitative reasoning occupy a more central place in the teaching and learning of science. At this stage, while science is still an integrated subject for all students, the separate disciplines of physics, chemistry, and biology begin to emerge. Also, formative and summative assessments include a practical element.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

For public schools, instruction in Dubai follows the national model provided by the UAE Ministry of Education. The ministry provides instructional materials free of charge for all students in public schools and equips all public schools with laboratories, learning resources rooms, and other rooms for scientific activity.

Teachers and Teacher Education

Teacher Education Specific to Mathematics and Science

For teachers in public schools, teacher education in Dubai follows the national model provided by the UAE Ministry of Education. Most teachers receive their education through a university degree program.

For teachers in private schools, preprimary teachers are required to have a university degree, diploma in education, or any relevant qualification and a minimum of two years experience in education. Primary teachers are required to have a university degree in teaching or primary education, or any relevant qualification and a minimum of two years experience teaching at the primary level. Specialist teachers must be qualified in their subject area. Secondary teachers must have a university degree in the subject area they teach, such as mathematics or science.

Requirements for Ongoing Professional Development

Graduates of education colleges complete significant periods of practical experience as a fundamental part of their studies. At some colleges, students devote several weeks each semester to training in schools through a student teacher program, while other colleges allocate the final semester for this purpose. Graduates do not receive any further subject-based training once placed in a teaching position.

Monitoring Student Progress in Mathematics and Science

Public schools follow the UAE's national system of assessment, which includes mid-year and end-of-year examinations in Grades 1–12. The end-of-year assessments are integrated across each educational zone and all of them are linked to the Ministry of Education objectives. Most of these examinations are in written form, and only a few require performance assessments.

Private schools throughout Dubai adopt the monitoring and assessment procedures related to their specific curricula. Many schools adapt the national assessment procedures of their country to suit the needs of their student population. For example, most UK schools adopt the English National Curriculum assessment processes. UK, International Baccalaureate, and Indian schools participate in external national or international examinations relevant to the curricula offered. US schools use a range of internal assessment tools and some participate in international benchmark tests in upper grades relevant to further and higher education placement.

Impact and Use of TIMSS

Dubai first participated in TIMSS in 2007 as a benchmarking participant. The assessment was administered at the same time that the Knowledge and Human Development Authority (KHDA) Dubai Schools Inspection Bureau was conducting a qualitative evaluation of schools. The TIMSS results were shared with schools in a TIMSS conference designed for school principals and teachers. In addition, the KHDA website and various publications made the outcomes for Dubai available to the public.

The result of participation in an international assessment was twofold recognition at a strategic level: the need for regular international assessments, and the need for all schools to be made aware of student achievement shortcomings in the areas of learning assessed within TIMSS. The Dubai Schools Inspection Bureau Inspection Handbook, used as the framework for school evaluation across all curricula (and public and private sectors), was amended to include reference to international standards. In this way, schools were required to check student achievement and progress not only against the schools' own curriculum standards, but also against international standards.[14]

Suggested Readings

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State of Florida

Florida Department of Education, 2012

Introduction

Overview of the Education System

The Florida Department of Education (FDOE) is the state education agency of Florida. It governs public education and manages funding and testing for local educational agencies. The Florida Commissioner of Education is the state's Chief Educational Officer.[1] The Office of the Commissioner of Education was originally directly responsible for education in Florida, and was a Cabinet-level position filled by direct election. By a 2003 constitutional amendment, the Governor assumed overall responsibility for FDOE. The amended constitution also created a new State Board of Education with seven members appointed by the Governor to oversee FDOE. The State Board now is responsible for appointing the Commissioner of Education.

FDOE serves and supports more than 2.6 million students, 180,000 teachers, 3,800 public schools, and 318,000 full-time staff in the state. Its annual operating budget in 2009–10 exceeded $19.3 billion.[2] FDOE serves as the single repository of education data from school districts, community colleges, universities, and independent postsecondary institutions, which allows for the tracking of student performance across time and various education sectors.

Florida law delegates the operation of primary and secondary schools to local governments, which in turn have traditionally assigned the task of running the schools to elected or appointed local school boards. These boards raise funds, establish policies and operating regulations, and hire or elect superintendents to manage and operate the district. The local district is responsible for curriculum decisions, implementation of standards, construction and maintenance of facilities, and operation of school programs.[3]

Florida Statute 1003.41 specifies that public K–12 instruction in Florida is based on content standards called the Sunshine State Standards. These content standards establish what every student in Florida needs to learn in mathematics and science. Section (1)(a)3 of the Statute states that the standards must include distinct grade level expectations for the core content knowledge and skills that a student is expected to have acquired by each individual grade level from kindergarten through Grade 8.

In September 2007, the State Board of Education revised the Sunshine State Standards as Florida's Next Generation Sunshine State Standards (NGSSS) for mathematics. Also in 2010, the State Board adopted the Common Core State Standards (CCSS) in mathematics.[4] CCSS were developed through a state-led consortium initiative to establish consistent and clear education standards for English and language arts and mathematics that would better prepare students for success in college, careers, and the competitive global economy.[5] Currently, CCSS serve as the basis for curriculum and instruction, professional development for teachers, instructional materials, and statewide assessment in Florida.

Florida has no specified state curriculum. However, Florida's content standards serve as the basis of instruction statewide and for State Board of Education approved course descriptions. Local school districts in Florida are responsible for determining the necessary curriculum and instructional scope and sequence to ensure that their students meet the state content standards. School districts also are responsible for developing and providing instructional and pedagogical guides for teachers.

Florida's approved courses, content standards, and resources are provided in the Course Code Directory and CPALMS (Collaborate, Plan, Align, Learn, Motivate, and Share) website, which was established in 2007.[6, 7] CPALMS is a state-wide infrastructure project to build information systems and tools to support the implementation of NGSSS and CCSS. Collaborators with CPALMS include K–12 teachers, researchers, FDOE, universities, district curriculum specialists, and many others.

CPALMS' Standards Information System is the core database of all components of Florida's standards, providing direct Internet access and connection to these standards, including mathematics and science. By integrating all standards into a single online system, CPALMS aims to do the following:

- Make the standards more practical by connecting them to courses;
- Make standards more achievable by providing high quality resources that are specifically aligned or created for the NGSSS;
- Provide standards-based tools to create high quality courses, instructional resources, planning and professional development; and
- Serve as "one source" for all standards-based information by utilizing the latest technologies such as Web 2.0, Internet services, and application

programming interfaces. This infrastructure will enable the creation of new standards-based tools and applications without the need to replicate the information systems within CPALMS.

Languages of Instruction

There is no official language in the United States. English is the most widely spoken language in the country and is the only language spoken by persons five years and over in 80 percent of homes. English is the language of instruction for academic subjects at all academic levels. The second most commonly spoken language at home is Spanish, spoken by twelve percent of the U.S. population.[8]

Florida's English language learners (ELLs) total over 260,000 students (about 10% of all Florida students), ranking Florida third among U.S. states in ELL population. Most of these students have Spanish as their native language. Florida's diversity of languages spoken by ELLs also surpasses most states in the country, with a total of 300. The League of United Latin American Citizens et al. v. State Board of Education Consent Decree is the state of Florida's framework for compliance with federal and state laws and jurisprudence regarding the education of English language learner students.

Mathematics Curriculum in Primary and Lower Secondary Grades

The goals and objectives for mathematics instruction are currently defined by Florida's Next Generation Sunshine State Standards for mathematics. Currently, Florida is transitioning from NGSSS to the Common Core State Standards with full implementation expected in the 2013–14 school year.

In Florida, mathematics course descriptions for kindergarten through Grade 8 are organized by grade level. The standards for Grades 9–12 are organized differently from those for kindergarten through Grade 8 and are written for particular courses under the following discipline headings: algebra, geometry, discrete mathematics, trigonometry, probability, statistics, calculus, and financial literacy. Middle school (Grades 5–8) courses also have an advanced track for those students pursuing high school credit for mathematics while in middle school.

Exhibit 1 presents the mathematics topics and skills generally taught by the end of Grade 4 in Florida. While the exhibit represents the content of the state standards generally, local curricula include detailed, grade-level instructional benchmarks, approaches to learning, and instructional resource material.

Exhibit 1: Mathematics Curriculum Topics Taught Through Grade 4

Area of Mathematics	Topics Covered by the End of Fourth Grade
Numbers	Concepts of whole numbers, including place value and ordering;
	Adding, subtracting, multiplying, and dividing with whole numbers;
	Concepts of fractions (fractions as parts of a whole or a collection, or as a location on a number line; and comparing and ordering fractions);
	Adding and subtracting with fractions;
	Concepts of decimals, including place value and ordering; and
	Number sentences (finding the missing number, modeling simple situations with number sentences).
Geometry	Comparing and drawing angles;
	Elementary properties of common geometric shapes;
	Reflections and rotations;
	Relationships between two-dimensional and three-dimensional shapes; and
	Finding and estimating areas, perimeters, and volumes.
Data and Chance	Reading data from tables, pictographs, bar graphs, or pie charts;
	Drawing conclusions from data displays;
	Displaying data using tables, pictographs, and bar graphs; and
	Number patterns (extending number patterns and finding missing terms).

Exhibit 2 presents the mathematics topics and skills generally taught by the end of Grade 8 in Florida. Using the same approach as for the fourth grade, this exhibit presents the general content in the state standards while local curricula include detailed, grade-level instructional benchmarks, approaches to learning, and instructional resource material.

Exhibit 2: Mathematics Curriculum Topics Taught Through Grade 8

Area of Mathematics	Topics Covered by the End of Eighth Grade
Numbers	Computing, estimating, or approximating with whole numbers;
	Concepts of fractions and computing with fractions;
	Concepts of decimals and computing with decimals;
	Representing, comparing, ordering, and computing with integers; and
	Problem solving involving percentages and proportions.
Algebra	Numeric, algebraic, and geometric patterns or sequences (extension, missing terms, and generalization of patterns);
	Simplifying and evaluating algebraic expressions;
	Simple linear equations and inequalities;
	Simultaneous equations in two variables; and
	Representation of functions as ordered pairs, tables, graphs, words, or equations.

Area of Mathematics	Topics Covered by the End of Eighth Grade
Geometry	Geometric properties of angles and geometric shapes (triangles, quadrilaterals, and other common polygons); Congruent figures and similar triangles; Relationship between three-dimensional shapes and their two-dimensional representations; Using appropriate measurement formulas for perimeter, circumference, area, surface area, and volume; Points on the Cartesian plane; and Translation, reflection, and rotation.
Data and Chance	Reading and displaying data using tables, pictographs, bar graphs, pie charts, and line graphs; Interpreting data sets (e.g., drawing conclusions, making predictions, and estimating values between and beyond given data points); and Judging, predicting, and determining chances of possible outcomes.

Science Curriculum in Primary and Lower Secondary Grades

The goals and objectives for science instruction are defined by Florida's Next Generation Sunshine State Standards for science, which consist of grade-specific benchmarks for each grade K–8 as well as grade-span benchmarks for Grades 9–12. Florida's course descriptions were developed from these standards, as were various resources to support teaching and learning. The science course descriptions for kindergarten through Grade 8 are organized by grade level. The standards for Grades 9–12 are organized differently from those for kindergarten through Grade 8 and are written for particular courses under the following discipline headings: nature of science, life science, physical science, and Earth and space science.

Exhibit 3 presents the science topics and skills generally taught by the completion of Grade 4 in Florida.

Exhibit 3: Science Curriculum Topics Taught Through Grade 4

Area of Science	Topics Covered by the End of Fourth Grade
Life Science	Life cycles and reproduction in plants and animals; Relationships in a given community (e.g., simple food chains, and predator-prey relationships); and Changes in environments (effects of human activity, and pollution and its prevention).
Physical Science	Classification of objects and materials based on physical properties (e.g., weight, mass, volume, and magnetic attraction); Familiar changes in materials (e.g., decaying, burning, rusting, and cooking); Common energy sources and forms and their practical uses; Light (e.g., sources and behavior); and Electrical circuits and properties of magnets.
Earth Science	Water on Earth (location, types, and movement); Air (composition, proof of its existence, and uses); Weather conditions from day to day or over the seasons; Earth's solar system (planets, sun, and moon); and Day, night, and shadows due to Earth's rotation and its relationship to the sun.

Exhibit 4 presents the science topics and skills generally taught by the completion of Grade 8 in Florida.

Exhibit 4: Science Curriculum Topics Taught Through Grade 8

Area of Science	Topics Covered by the End of Eighth Grade
Biology	Major organs and organ systems in humans and other organisms (structure and function, and life processes that maintain stable bodily conditions); Cells and their functions, including respiration and photosynthesis as cellular processes; Reproduction (sexual and asexual) and heredity (passing on of traits, and inherited versus acquired or learned characteristics); Role of variation and adaptation in survival and extinction of species in a changing environment; and Interdependence of populations of organisms in an ecosystem (e.g., energy flow, food webs, competition, and predation) and the impact of changes in the physical environment on populations (e.g., climate and water supply).
Chemistry	Classification, composition, and particulate structure of matter (elements, compounds, mixtures, molecules, atoms, protons, neutrons, and electrons); Chemical change (transformation of reactants, evidence of chemical change, conservation of matter, and common oxidation reactions including combustion, rusting, and tarnishing); Solutions (solvent, solute, concentration and dilution, and the effect of temperature on solubility); and Properties and uses of common acids and bases.

Area of Science	Topics Covered by the End of Eighth Grade
Physics	Physical states and changes in matter (explanations of properties in terms of movement and distance between particles; and phase change, thermal expansion, and changes in volume and pressure); Energy forms, transformations, heat, and temperature; Basic properties and behaviors of light (reflection, refraction, light and color, and simple ray diagrams) and sound (transmission through media, loudness, pitch, amplitude, frequency, and relative speed of light and sound; Electric circuits (flow of current; parallel and series circuits; and the relationship between current and voltage) and properties and uses of permanent magnets and electromagnets; and Forces and motion (types of forces, basic description of motion, and effects of density and pressure).
Earth Science	Earth's structure and physical features (Earth's crust, mantle and core; composition and relative distribution of water; and composition of air); Earth's processes, cycles and history (rock cycle; water cycle; weather patterns; major geological events; and formation of fossils and fossil fuels); Earth's resources, their use, and conservation (renewable v. nonrenewable resources, human use of land and soil, and water resources); and Earth in the solar system and the universe (day and night, tides, phases of moon, eclipses, seasons on Earth; physical features of Earth compared to other bodies; and the sun as a star).

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Materials, Equipment, and Laboratories

Florida Statutes govern the adoption process for Florida's instructional materials. FDOE develops policies and procedures for the adoption of instructional materials annually, identifying subject areas for material adoption each year on a rotating basis. Prior to each adoption, FDOE publishes Instructional Materials Specifications for the subjects to be adopted. These specifications outline the courses for which materials are being sought, as well as the standards that those materials are expected to meet. State Instructional Materials Reviewers evaluate the materials submitted for adoption, and the Commissioner of Education formally adopts the recommendations of the reviewers, either fully or with amendments.

Each district (Local Education Agency) may choose which materials to purchase from this adoption list. Florida schools and school districts must purchase adopted materials through the publisher's Florida depository. Florida Statutes stipulate that funding for instructional materials is allocated to local school districts annually, as determined by the legislature. Up to 50 percent of this annual allocation may be used for materials not on the state-adopted list. By the 2015–16 school year, each district is required to use at least 50 percent of the annual allocation for the purchase of digital or electronic instructional materials included on the list of state-adopted instructional materials.[9]

Use of Technology

Florida has not adopted technology standards for students statewide. The state does, however, support the International Society for Technology in Education—National Educational Technology Standards (ISTE-NETS) for Students.[10] Some school districts in the state have adopted their own technology standards.

Florida's Next Generation Sunshine State Standards do not contain statements or policies about the use of calculators for Grade 4 or Grade 8 mathematics tests or examinations; however, the FCAT test item specifications include the following statement related to calculator use:

> At Grades 3–6, all items should be written so they can be answered without using a calculator. At Grades 7 and 8, students are allowed to use a four-function calculator, although items should still be written to be answered without a calculator within the timing guidelines for each item type. For the Algebra 1 [End of Course] EOC Assessment, a four-function calculator will also be allowed. For the Geometry EOC Assessment, a scientific calculator will be used.[11]

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Under the federal No Child Left Behind (NCLB) Act of 2002, all middle and upper secondary teachers (Grades 6–12) are required to be specialists within their fields. Florida's elementary educator certification allows teachers to teach up to the Grade 6 level.

Homework Policies

Florida has not adopted a statewide policy related to homework. The amount of time students at a given grade level are expected to spend on mathematics and science homework in a given week varies according to the policies established by local school districts, schools, and teachers. In general, educational activities completed at home are viewed as opportunities for practicing skills and reinforcing understanding of material learned in the classroom.

Teachers and Teacher Education

Florida's "traditional" state-approved pathway for public school teachers is completion of an Initial Teacher Preparation program, which requires candidates to demonstrate mastery of three areas: general knowledge, professional preparation and education competence, and subject area knowledge in one or more specific subject areas. These programs are offered at Florida postsecondary institutions and include a culminating supervised teaching experience of at least ten weeks. Individuals who complete an Initial Teacher Preparation program earn a bachelor's or master's degree in education specific to the subject area in which they are being prepared. For example, individuals in a program specific to primary education (Grades K–6) earn a degree in primary education, while individuals in a program specific to secondary mathematics (Grades 6–12) earn a degree in mathematics education.

During the 2009–10 academic year, 81 percent of individuals who completed a Florida Initial Teacher Preparation program completed their program at the bachelor's degree level and could be considered "traditional" entrants to the teaching profession. That same academic year, 3 percent of individuals completed a five-year program resulting in a bachelor's and master's degree. Finally, 16 percent of individuals completed their program at the master's degree level and could have demonstrated mastery of subject area knowledge by holding a bachelor's degree in the appropriate subject area, by completing the appropriate subject area content courses, or by passing a subject area test.

Florida public school teachers must be certified by FDOE. Most four-year colleges and universities, public and private, have a department or school of education offering teacher education programs aligned with state certification requirements. Florida issues a three-year non-renewable Temporary Certificate and a five-year renewable Professional Certificate. The Professional Certificate requires passing scores on a general knowledge exam, a subject area knowledge exam, and a general pedagogy exam. Florida also has two alternative certification programs approved by FDOE: the District Alternative Certification Program, and Educator Preparation Institutes. The District Alternative Certification Program requires that participants hold a valid Temporary Certificate while employed as full-time teachers. Both alternative certification programs require participants to have completed a bachelor's degree.

In the 2010–11 school year, 100 percent of Florida's more than 185,000 primary and secondary public school teachers had at least a bachelor's degree, and 41 percent also had a master's degree or other degree or certificate beyond a bachelor's degree.[12]

Requirements for Ongoing Professional Development

Florida requires continuing professional development and education for the renewal of teacher certificates. School districts and educational consortia that assist smaller school districts provide opportunities for teachers to continue their education through professional development activities organized by the school district. Many districts have professional development coordinators or specialists whose primary focus is to assist teachers with completing professional development and attaining credits toward re-certification.[13]

The Florida Professional Development Evaluation System guides a district's professional development activities. This evaluation system assesses local planning, delivery, follow-up, and evaluation of professional development activities according to standards modeled after the Learning Forward (formerly the National Staff Development Council) standards, as well as Florida Statutory requirements. The Florida Professional Development Evaluation System Protocol includes standards that identify and recognize best practices as well as local professional development systems in need of improvement.

Professional development in Florida is linked directly to identified student needs. Principals are required to maintain individual professional development plans for instructional personnel, which are based on the needs of students in the classrooms to which they are assigned. Consequently, professional development activities are selected and scheduled locally to correspond to specific schools' student needs.

Monitoring Student Progress in Mathematics and Science

Florida's accountability system is governed by Florida Statute 1008, Assessment and Accountability. Key components of this system include a school grading system that assigns letter grades (A–F) to each public school, based primarily on student performance, and the Florida Comprehensive Assessment Test (FCAT), measuring student achievement in reading, mathematics, science, and writing.

Florida's Student Progression Planning Guide provides the required elements of a Student Progression Plan.[14] Florida public schools typically issue grade reports every six weeks for students in Grades K–5 and every nine weeks for students in Grades 6–12. Semester grades and yearly grades also are given in many districts. Florida Statutes include requirements for middle grade promotion (from Grade 8 to Grade 9) and high school graduation. The latter include a minimum grade point average (GPA) as well as a minimum number of credits (including some specific course credits).[15] High school transcripts that show courses taken and grades earned are used to establish whether students have met the state's graduation requirements. Transcripts also are used in college entrance applications as a record of academic performance.

FCAT for mathematics is developed at the state level and administered to all students in Grades 3 through 8 as well as Grade 10. The Algebra 1 End of Course (EOC) exam was administered for the first time in 2010–11. The FCAT science assessments are administered to all students in Grades 5 and 8. The Biology EOC exam will be administered for the first time in 2011–12.

Florida students enrolled in Advanced Placement, International Baccalaureate, or Advanced International Certification of Education programs also participate in tests associated with these programs. In addition, all Florida students have the opportunity to take the Preliminary Scholastic Aptitude Test during high school.

Suggested Readings

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Appendix

Organizations and Individuals Responsible for TIMSS 2011

Introduction

TIMSS 2011 was a collaborative effort involving hundreds of individuals around the world. This appendix acknowledges the individuals and organizations for their contributions. Given that work on TIMSS 2011 has spanned approximately four years and has involved so many people and organizations, this list may not include all who contributed. Any omission is inadvertent. TIMSS 2011 also acknowledges the students, parents, teachers, and school principals who contributed their time and effort to the study. This report would not be possible without them.

Management and Coordination

TIMSS is a major undertaking of IEA, and together with the Progress in International Reading Literacy Study (PIRLS), comprises the core of IEA's regular cycles of studies. The TIMSS assessment at the fourth grade complements PIRLS, which regularly assesses reading achievement at fourth grade.

The TIMSS & PIRLS International Study Center at Boston College has responsibility for the overall direction and management of the TIMSS and PIRLS projects. Headed by Executive Directors Drs. Ina V.S. Mullis and Michael O. Martin, the study center is located in the Lynch School of Education. In carrying out the project, the TIMSS & PIRLS International Study Center worked closely with the IEA Secretariat in Amsterdam, which managed country participation, was responsible for verification of all translations produced by the participating countries, and coordinated the school visits by International Quality Control Monitors. The IEA Data Processing and Research Center in Hamburg was responsible for processing and verifying the data submitted by the participants; Statistics Canada in Ottawa was responsible for school and student sampling activities; and Educational Testing Service in Princeton, New Jersey consulted on psychometric methodology, provided software for scaling the achievement data, and replicated the achievement scaling for quality assurance.

The Project Management Team, comprising the study directors and representatives from the TIMSS & PIRLS International Study Center, IEA Secretariat and IEA Data Processing and Research Center, Statistics Canada, and ETS met twice a year throughout the study to discuss the study's progress, procedures, and schedule. In addition, the study directors met with members of IEA's Technical Executive Group twice yearly to review technical issues.

To work with the international team and coordinate within-country activities, each participating country designates an individual to be the TIMSS National Research Coordinator (NRC). The NRCs have the challenging task of implementing TIMSS in their countries in accordance with the TIMSS guidelines and procedures. In addition, the NRCs provide feedback and contributions throughout the development of the TIMSS assessment. The quality of the TIMSS assessment and data depends on the work of the NRCs and their colleagues in carrying out the complex sampling, data collection, and scoring tasks involved. Continuing the tradition of exemplary work established in previous cycles of TIMSS, the TIMSS 2011 NRCs performed their many tasks with dedication, competence, energy, and goodwill, and have been commended by the IEA Secretariat, the TIMSS & PIRLS International Study Center, the IEA Data Processing and Research Center, and Statistics Canada for their commitment to the project and the high quality of their work.

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