TRENDS IN INTERNATIONAL MATHEMATICS AND SCIENCE STUDY

TIMSS

TIMSS 2007 Encyclopedia

A Guide to Mathematics and Science Education Around the World

Volume 1

A–L

Edited by

Ina V.S. Mullis

Michael O. Martin

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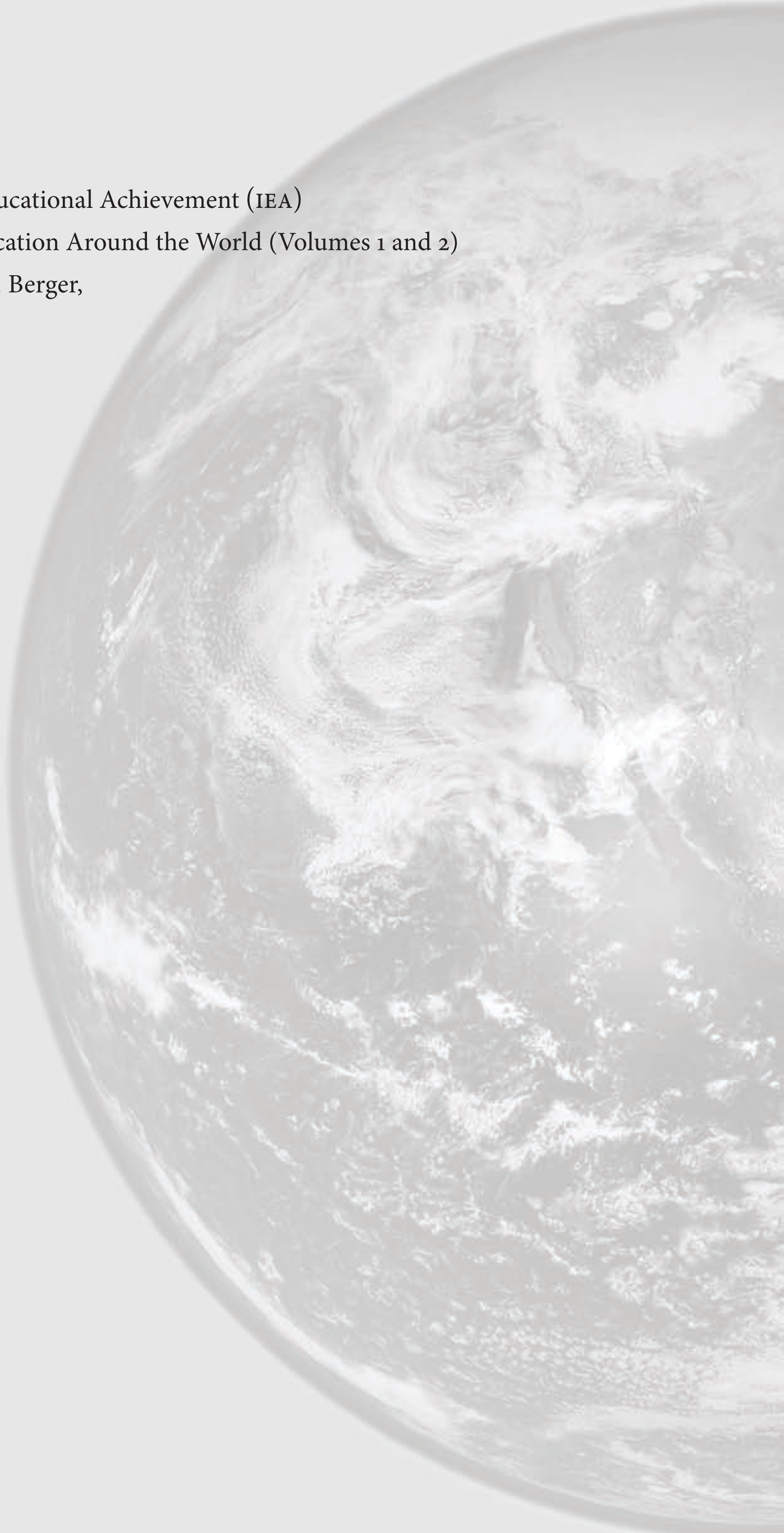

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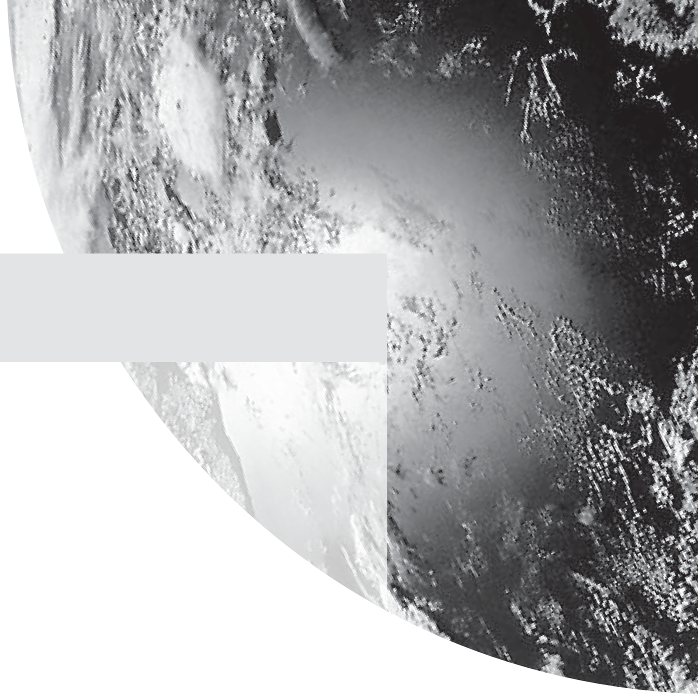


Foreword

Excellence in the teaching and learning of mathematics and science remains at the forefront of educational concerns for nations and other subnational jurisdictions wishing to prepare their students for 21st century knowledge-based economies. As it enters its second decade, the IEA Trends in Mathematics and Science Study (TIMSS) remains at the forefront of international, large scale, comparative studies of educational achievement that provide educators, policy-makers, and the wider community alike with fundamental strategic information related to the performance of their education systems.

As is the case for all of IEA's major assessment initiatives, the assessment of students' opportunity to learn is one of the guiding principles in the overall design of TIMSS. The *TIMSS 2007 Encyclopedia: A Guide to Mathematics and Science Education Around the World* describes the *intended curriculum*; the mathematics and science curriculum as it is intended to be taught in each of the countries participating in TIMSS 2007. It also describes countries' education systems and policies, so that the encyclopedia provides a detailed insight into the educational practices that guide mathematics and science instruction. The qualitative information used in the *TIMSS 2007 Encyclopedia* is intended to complement the quantitative data that are contained in the *TIMSS 2007 International Mathematics Report* and the *TIMSS 2007 International Science Report*. Together with the TIMSS 2007 international reports, the information in the *TIMSS 2007 Encyclopedia* can be used to examine the relationships among policy and curricular expectations, instructional practices, and achievement outcomes within and among participating countries.

The success of the TIMSS project, as has been the case for more than a decade, relies on exceptional professionals at the TIMSS & PIRLS International Study Center, Lynch School of Education, Boston College who provide the leadership for this project, as well as on key personnel from the other members of the IEA consortium, including Statistics Canada, Educational Testing Service, the IEA Secretariat, and the IEA Data Processing Center.

As in previous cycles, the TIMSS Executive Directors Drs. Ina Mullis and Michael Martin provided the intellectual and organizational leadership that is critical for the success of this project and IEA is indebted for their continued exemplary leadership.

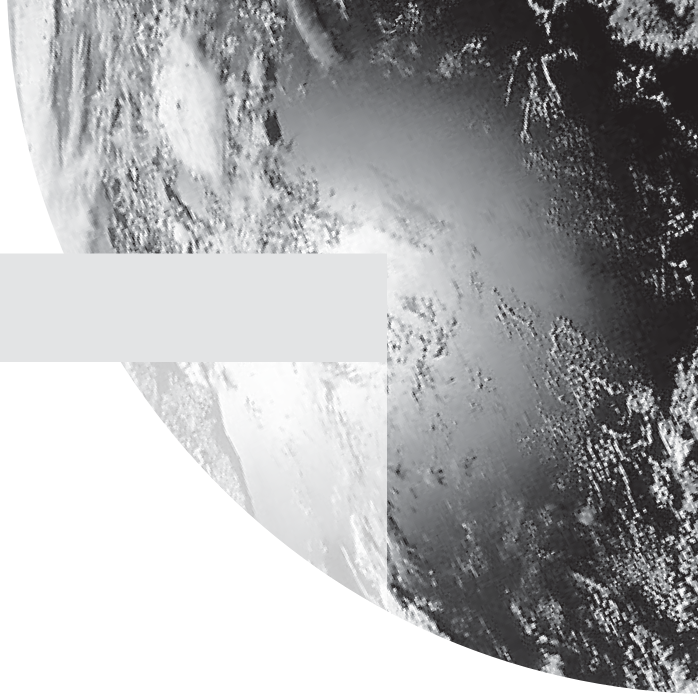
The authors of the chapters in this publication are to be congratulated and deserve the majority of the credit for the *TIMSS 2007 Encyclopedia*. Their expertise, dedication, and hard work made it possible. Also, many people at the TIMSS & PIRLS International Study Center contributed their skills and expertise to its production, including, in particular, the TIMSS Project Coordinator, Dr. John Olson, as well as Debra Berger, Dana Milne, and Gabrielle Stanco, who tirelessly applied their editorial skills, reading and re-reading successive drafts. Mario Pita was responsible for the design of this publication, and worked with Ruthanne Ryan and Jennifer Moher to coordinate production.

As with all IEA publications, the IEA Publications Committee reviewed the two-volume *TIMSS 2007 Encyclopedia* and for this, IEA is extremely grateful. Dr. David Robitaille, chair, assisted by Robert Garden, provided valuable input and suggestions for improvement.

Ultimately, projects of the magnitude of TIMSS are not possible without considerable financial support. The U.S. National Center for Education Statistics, IEA's major funding partner, together with support from the World Bank, the United Nations Development Programme, and those countries that contributed by way of fees have ensured the successful completion of the largest study of its type in a widely differing range of countries. I also would like to express my thanks to Boston College and the National Foundation for Educational Research for their continuing support.

Finally, projects such as TIMSS depend on the commitment and dedication of policy-makers and researchers in participating countries. Their support, combined with the willingness of principals, teachers, and students to participate in these endeavors, make possible the TIMSS assessments that enhance the quality of education. Also, to the National Research Coordinators whose responsibility it was to manage and conduct the study at the national level and who ensure the success of TIMSS, I express my thanks.

Dr. Hans Wagemaker
Executive Director, IEA



Introduction

Overview of TIMSS

The goal of IEA's TIMSS (Trends in International Mathematics and Science Study) is to help countries make informed decisions about how to improve teaching and learning in mathematics and science. In brief, TIMSS provides comparative information about mathematics and science achievement at the fourth and eighth grades across countries in relation to the various curriculum and instructional approaches used. This enables policy makers and educators to focus on the quality of educational achievement, to monitor curricular implementation and effectiveness, and identify promising instructional practices.

The IEA (International Association for the Evaluation of Educational Achievement) is an independent international co-operative of national research institutions and governmental agencies with a permanent secretariat based in Amsterdam, the Netherlands. A pioneer in the field of international assessments, the IEA has been conducting large-scale comparative studies of educational achievement for the past 50 years. In IEA's long history of collecting information about mathematics and science education, the first assessment of TIMSS in 1995 began a series of rigorous and progressive international assessments designed to measure progress in achievement over time and across grades.

Conducted on a regular 4-year cycle, TIMSS has assessed mathematics and science in 1995, 1999, 2003, and 2007, with planning underway for 2011. In addition to monitoring trends in achievement at the fourth and eighth grades, TIMSS provides information about relative progress across grades as the cohort of students assessed at the fourth grade in one cycle moves to the eighth grade 4 years later (e.g., the fourth grade students of 2003 became the eighth grade students of 2007).

To provide comparative perspectives on trends in achievement in the context of different education systems, school organizational approaches, and instructional practices, TIMSS 2007 collected a rich array of background information. Students, as well as their teachers and school principals, completed questionnaires to provide information about the school and classroom situations for teaching and learning in mathematics and science. Countries completed online questionnaires about their education systems, mathematics and science curricula, and resources for mathematics and science instruction. To expand on the information provided in the questionnaires, countries also prepared chapters for this two-volume publication, the *TIMSS 2007 Encyclopedia: A Guide to Mathematics and Science Education Around the World*, to further describe their educational and curricular contexts in mathematics and science.

The Purpose of the TIMSS 2007 Encyclopedia

The results of high-quality international assessments such as TIMSS 2007 can contribute significantly to debates about how to improve educational quality and equity. Yet, countries are very different from one another in fundamental ways, and education systems, as products of particular cultures, also are very different from one another. Because of these differences, it is very important to interpret the TIMSS 2007 achievement results in light of the contexts for mathematics and science instruction within the countries and benchmarking entities (educational regions, states, or provinces within countries).

The *TIMSS 2007 Encyclopedia* provides the countries and benchmarking participants the opportunity to describe their national contexts for mathematics and science education as well as their mathematics and science curricula. The more qualitative information provided in the *TIMSS 2007 Encyclopedia* is intended to complement both the *TIMSS 2007 International Mathematics Report*[1] and the *TIMSS 2007 International Science Report,*[2] which contain the results from the TIMSS 2007 mathematics and science assessments at the fourth and eighth grades, including trends over time in achievement and the educational contexts for mathematics and science instruction. To complete the set of publications, the *TIMSS 2007 Assessment Frameworks*[3] contains the mathematics and science frameworks underlying the assessments at the fourth and eighth grades, and the contextual framework for the questionnaires, and the *TIMSS 2007 Technical Report*[4] provides technical documentation about the development and implementation of the assessments.

One of the most important features of IEA studies is the substantial effort expended to address the more substantive and important questions about the meaning of the achievement results. TIMSS attempts to deepen understanding of the effects of policies and practices within and across systems of education internationally. To provide an overview of the context in which mathematics and science instruction takes place, nearly all of the TIMSS 2007 countries and benchmarking participants prepared a chapter summarizing the structure of their education systems, the mathematics and science curricula and instruction in primary and secondary grades, the teacher education requirements, and the types of examinations and assessments employed. Together with selected introductory data about the countries collected via questionnaires, the chapters comprising the *TIMSS 2007 Encyclopedia* are intended to provide an important resource for helping to understand the context for the teaching and learning of mathematics and science around the world, with particular emphasis on schooling through the eighth grade.

The chapters were written primarily by experts from ministries of education, research institutes, or institutions of higher education who had extensive knowledge about the education system in their country. The authors often were the individuals also responsible for implementing TIMSS 2007 in their countries. To provide a common structure from chapter to chapter, a detailed outline was prepared and agreed upon by the participating countries. Therefore, there are similarities across countries in the topics discussed.

The Importance of Country and School Contexts in Making International Comparisons

A country's education system is the result of a series of decisions and compromises made in response to the specific goals, priorities, politics, resources, and historical traditions of its government representatives and citizens. There is an important distinction between system-level parameters and the school and classroom situations where actual instruction takes place. The decisions about educational organization, structure, resources, facilities, teacher qualifications, and curriculum often are separate from what actually gets taught. In IEA terms, there is a difference between the intended curriculum, as specified in official documents, and the implemented curriculum that actually is taught in schools. The learning goals described in the intended curriculum generally result from economic, political, and social priorities, while what is actually taught can be more closely associated with school and classroom conditions including the background and experiences of teachers and students.

The *TIMSS 2007 Encyclopedia* was developed specifically to describe a number of the factors influencing the intended curriculum within each participating country and to present the intended mathematics and science curricula through the eighth grade. The culture of the country, including the value placed on education, learning, and mathematics and science achievement, is a powerful influencing factor as is its economic health and the diversity of its citizenry. Within this context, some countries have centralized education systems and others have decentralized decision-making structures. In many countries, the locus of decision making can differ depending on the particular policies. For example, there often are national regulations about the number of years of compulsory schooling, the structure of the education system, and the criteria for students receiving certificates of completion or diplomas. Also, many countries have a nationally recognized curriculum, whereas others have a more decentralized approach to curricular decisions.

Each chapter summarizes the curriculum intended to guide mathematics and science instruction through the eighth grade. There is considerable information about the skills and strategies that children were expected to have studied and learned prior to the TIMSS 2007 assessment. Textbooks, instructional materials, instructional time, technological resources, and laboratory facilities are described because they serve and reflect the priorities of the intended curriculum. Teacher education and professional development also is described to provide information about the way teachers are trained before they begin in the field and how they are supported once they start teaching. Assessment and examination systems are also covered because they provide information to identify students needing remediation, suggest instructional programs needing improvement, and further support the expected outcomes of the education system.

The *TIMSS 2007 Encyclopedia* provides an important vehicle for beginning to compare and contrast the common and the unique features of the country contexts and curricular goals used in teaching mathematics and science around the world. For example, because of similarities in culture, it might be anticipated that the Asian countries with high achievement on TIMSS assessments would have similarities in their educational approaches. Based on the information included in the chapters by Chinese Taipei, Hong Kong SAR, Japan, the Republic of Korea, and Singapore, there are commonalities in the importance and high priority given to education, as well as in how education is structured. All five countries have a unitary administration system for education and a coherent, integrated curriculum for both mathematics and science through the ninth grade (or beyond). Their curricula are well developed, supported with ministry-recommended textbooks, and academically rigorous. In mathematics, for instance, the algebra curricula encompassing the eighth grade include understanding and using simultaneous linear equations with two unknowns, linear inequalities with one unknown, and linear functions.

The high-achieving Asian countries also appear to focus on continued reform and improvement in education. For example, Chinese Taipei has implemented the Integrated Curricula and Multi-route Promotion Programs and in 2002 convened the First National Congress on Science Education to develop the blueprint to improve science education. Hong Kong SAR, with a Curriculum Development Council to advise government and the Curriculum Development Institute to support schools in the implementation and curriculum policies and innovations, is restructuring its education system to have 6 rather than 7 years of secondary education in order to provide an additional year of university (4 rather than 3 years). The curriculum in Japan undergoes periodic revision to keep up with societal changes, and the amount of content and the number of class periods spent on mathematics and science will increase with the next revision beginning in 2011. The curricular approaches in these countries include provisions for different rates of student learning through such practices as streaming (Singapore), special supplementary classes for failing students and in-depth courses for gifted students (Korea), or designating some upper secondary schools that emphasize science, technology, and mathematics education as "super science high schools" to foster promising scientists and engineers (Japan). All five emphasize and support technology in various ways, for example, the 2004 e-Japan Priority Policy Program Plan, the Blueprint for Information Education for Primary and Secondary Schools in Chinese Taipei, and the Technology Education Good Practices Sharing Scheme launched in secondary schools in Hong Kong SAR. Also, all have examination systems that determine schooling opportunities, particularly, entrance to universities.

The information in the chapters reveals that many other TIMSS 2007 countries and benchmarking participants have aspects of their educational systems and curricular approaches that are similar to those described above, including well developed curricula, a focus on educational reform, and examination systems. Indeed, from country to country and considering all of the dimensions of mathematics and science education described, almost all countries have a number of similarities with other countries. No two countries, however, are similar to each other in every respect.

One of the most important uses of the *TIMSS 2007 Encyclopedia* is to gain a sense of the uniqueness of each educational setting. All the countries have the common goal of teaching their children mathematics and science, yet the national and regional contexts and the instructional situations differ dramatically depending on many country characteristics, including resources, culture, demographics, and educational philosophies. The next sections of the Introduction provide more detailed information about the wide variety of educational contexts represented across the countries that participated in TIMSS 2007. After the Introduction, the country chapters are presented in alphabetical order, followed by the chapters for the benchmarking participants, also in alphabetical order.

Demographics of TIMSS 2007 Participants

TIMSS 2007 involved widespread participation from around the world. Exhibit 1 shows a map of the world identifying the TIMSS 2007 countries and benchmarking participants (regional entities). In Exhibit 1, the 59 participating countries and 8 benchmarking participants are listed alphabetically and shown by their geographic location. The decision to participate in any IEA study is coordinated through the IEA Secretariat in Amsterdam and made solely by each member country according to its own data needs and resources.

Exhibit 2 lists the TIMSS 2007 participants, and indicates the grade(s) at which they participated and the previous cycles they participated in at that grade. It can be seen that many of the TIMSS 2007 countries and benchmarking participants have data for both the fourth and eighth grades. Exhibit 2 also shows that most TIMSS 2007 participants have trend data and, for each participant, whether it is for two, three, or four points in time—1995, 1999, 2003, and 2007.

Exhibit 3 presents selected information about the demographic and economic characteristics of the TIMSS 2007 countries, because such factors can influence educational policies and decision-making. As can be seen, the TIMSS 2007 countries vary widely in population size and geographic area, as well as in population density. The countries also vary widely on indicators of health, such as life expectancy and infant mortality rate. The majority of countries had life expectancies of 70 to 79 years, and infant mortality rates of between 3 and 20 out of 1,000 births. However, at one end of the continuum, 11 of the countries had a life expectancy of 80 years or more and a low infant mortality rate (5 or fewer infant deaths per 1,000 live births), while Ghana and Yemen had life expectancies of about 60 years and Botswana of 50 years, and these three had the highest infant mortality rates (approximately 75 and 90 infant deaths per 1,000 live births, respectively).

Exhibit 1 Countries Participating in TIMSS 2007

TIMSS2007 Mathematics & Science 4th & 8th Grades

Algeria
Armenia
Australia
Austria
Bahrain
Bosnia and Herzegovina
Botswana
Bulgaria
Chinese Taipei
Colombia
Cyprus
Czech Republic
Denmark
Egypt
El Salvador
England
Georgia
Germany
Ghana
Hong Kong SAR
Hungary
Indonesia
Iran, Islamic Rep. of
Israel
Italy
Japan
Jordan
Kazakhstan
Korea, Rep. of
Kuwait
Latvia
Lebanon
Lithuania
Malaysia
Malta
Mongolia
Morocco
Netherlands
New Zealand
Norway
Oman
Palestinian Nat'l Auth.
Qatar
Romania
Russian Federation
Saudi Arabia
Scotland
Serbia
Singapore
Slovak Republic
Slovenia
Sweden
Syrian Arab Republic
Thailand
Tunisia
Turkey
Ukraine
United States
Yemen

Benchmarking Participants
Alberta, Canada
Basque Country, Spain
British Columbia, Canada
Dubai, UAE
Massachusetts, US
Minnesota, US
Ontario, Canada
Quebec, Canada

Exhibit 1 Countries Participating in TIMSS 2007 (Continued)

Exhibit 2 Countries Participating in TIMSS 1995 Through 2007

TIMSS2007 Mathematics & Science 4th & 8th Grades

Country	Grade 4			Grade 8			
	2007	2003	1995	2007	2003	1999	1995
Algeria	●			●			
Armenia	●	●		●	●		
Australia	●	●	●	●	●	●	●
Austria	●		●				●
Bahrain				●	●		
Bosnia and Herzegovina				●			
Botswana				●	●		
Bulgaria				●	●	●	●
Chinese Taipei	●	●		●	●	●	
Colombia	●			●			●
Cyprus		●	●	●	●	●	●
Czech Republic	●		●	●		●	●
Denmark	●						●
Egypt				●	●		
El Salvador	●			●			
England	●	●	●	●	●	●	●
Georgia	●			●			
Germany	●						●
Ghana				●	●		
Hong Kong SAR	●	●	●	●	●	●	●
Hungary	●	●	●	●	●	●	●
Indonesia				●	●	●	
Iran, Islamic Rep. of	●	●	●	●	●	●	●
Israel			●	●	●	●	●
Italy	●	●	●	●	●	●	●
Japan	●	●	●	●	●	●	●
Jordan				●	●	●	
Kazakhstan	●						
Korea, Rep. of			●	●	●	●	●
Kuwait	●		●	●			●
Latvia	●	●	●		●	●	●
Lebanon				●	●		
Lithuania	●	●		●	●	●	●
Malaysia				●	●	●	
Malta				●			
Mongolia	●			●			
Morocco	●	●		●	●	●	
Netherlands	●	●	●		●	●	●
New Zealand	●	●	●		●	●	●
Norway	●	●	●	●	●		●
Oman				●			
Palestinian Nat'l Auth.				●	●		
Qatar	●			●			
Romania				●	●	●	●
Russian Federation	●	●		●	●	●	●
Saudi Arabia				●	●		

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2007

Exhibit 2 Countries Participating in TIMSS 1995 Through 2007 (Continued)

TIMSS2007 Mathematics & Science 4th & 8th Grades

Country	Grade 4			Grade 8			
	2007	2003	1995	2007	2003	1999	1995
Scotland	●	●	●	●	●		●
Serbia				●	●		
Singapore	●	●	●	●	●	●	●
Slovak Republic	●				●	●	●
Slovenia	●	●	●	●	●	●	●
Sweden	●			●	●		●
Syrian Arab Republic				●	●		
Thailand			●	●		●	●
Tunisia	●	●		●	●	●	
Turkey				●		●	
Ukraine	●			●			
United States	●	●	●	●	●	●	●
Yemen	●	●					
Benchmarking Participants							
Alberta, Canada	●		●			●	●
Basque Country, Spain				●	●		
British Columbia, Canada	●			●		●	
Dubai, UAE	●			●			
Massachusetts, US	●			●		●	
Minnesota, US	●		●	●			●
Ontario, Canada	●	●	●	●	●	●	●
Quebec, Canada	●	●	●	●	●	●	●

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2007

Exhibit 3 Selected Characteristics of TIMSS 2007 Countries

TIMSS2007 Mathematics & Science 4th & 8th Grades

Country	Population Size (in Millions)[1]	Area of Country (Square Kilometers)[2]	Population Density (People per Square Kilometer)[3]	Urban Population (% of Total)[4]	Life Expectancy at Birth (Years)[5]	Infant Mortality Rate (per 1,000 Live Births)[6]	Gross National Income per Capita (in US Dollars)[7]	GNI per Capita (Purchasing Power Parity)[8]
Algeria	33.4	2381700	14	64	72	33	3030	5940
Armenia	3.0	28200	107	64	72	21	1920	4950
Australia	20.7	7682300	3	88	81	5	35860	33940
Austria	8.3	82500	100	66	80	4	39750	36040
Bahrain	0.7	700	1041	97	76	9	19350	34310
Bosnia and Herzegovina	3.9	51200	77	46	75	13	3230	6780
Botswana	1.9	566700	3	58	50	90	5570	11730
Bulgaria	7.7	108600	71	70	73	12	3990	10270
Chinese Taipei	23.0	36000	634	70	78	5	17294	–
Colombia	45.6	1109500	41	73	73	17	3120	6130
Cyprus	0.8	9300	84	70	79	3	23270	25060
Czech Republic	10.3	77300	133	74	77	3	12790	20920
Denmark	5.4	42400	128	86	78	4	52110	36190
Egypt	74.2	995500	75	43	71	29	1360	4940
El Salvador	6.8	20720	326	60	72	22	2680	5610
England	50.4	130000	390	90	79	5	40560	33650
Georgia	4.4	69500	64	52	71	28	1580	3880
Germany	82.4	348800	236	75	79	4	36810	32680
Ghana	23.0	227500	101	49	60	76	510	1240
Hong Kong SAR	6.9	1000	6581	100	82	–	29040	39200
Hungary	10.1	89600	112	67	73	6	10870	16970
Indonesia	223.0	1811600	123	49	68	26	1420	3310
Iran, Islamic Rep. of	70.1	1628600	43	67	71	30	2930	9800
Israel	7.1	21600	326	92	80	4	20170	23840
Italy	58.8	294100	200	68	81	4	31990	28970
Japan	127.8	364500	351	66	82	3	38630	32840
Jordan	5.5	88200	63	83	72	21	2650	4820
Kazakhstan	15.3	2699700	6	58	66	26	3870	8700
Korea, Rep. of	48.4	98700	490	81	79	5	17690	22990
Kuwait	2.6	17800	146	98	78	10	30630	48310
Latvia	2.3	62400	37	68	71	8	8100	14840
Lebanon	4.1	10200	396	87	72	26	5580	9600
Lithuania	3.4	62700	54	67	71	7	7930	14550
Malaysia	26.1	328600	80	68	74	10	5620	12160
Malta	0.4	300	1269	96	79	5	15310	20990
Mongolia	2.6	1566500	2	57	67	34	1000	2810
Morocco	30.5	446300	68	59	71	34	2160	3860
Netherlands	16.3	33900	482	81	80	4	43050	37940
New Zealand	4.2	267700	16	86	80	5	26750	25750
Norway	4.7	304300	15	78	80	3	68440	50070
Oman	2.5	309500	8	72	76	10	11120	19740
Palestinian Nat'l Auth.	3.9	6000	648	57	72	29	1374	–
Qatar	0.8	11000	75	96	76	18	–	–
Romania	21.6	230000	94	54	72	16	4830	10150
Russian Federation	142.5	16381400	9	73	66	14	5770	12740
Saudi Arabia	23.7	2000000	12	81	73	21	13980	22300
Scotland	5.1	78000	66	82	77	5	40560	33650
Serbia	7.4	102000	84	52	73	7	4030	9320
Singapore	4.5	700	6508	100	80	2	28730	43300
Slovak Republic	5.4	48100	112	56	74	7	9610	17060
Slovenia	2.0	20100	100	51	78	3	18660	23970
Sweden	9.1	410300	22	84	81	3	43530	34310
Syrian Arab Republic	19.4	183800	106	51	74	12	1560	4110
Thailand	63.4	510900	124	33	70	7	3050	7440
Tunisia	10.1	155400	65	66	74	19	2970	6490
Turkey	73.0	769600	95	68	72	24	5400	8410
Ukraine	46.8	579400	81	68	68	20	1940	6110
United States	299.4	9161900	33	81	78	7	44710	44070
Yemen	21.7	527900	41	28	62	75	760	2090

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2007

Exhibit 3 Selected Characteristics of TIMSS 2007 Countries (Continued)

TIMSS2007 Mathematics & Science 4th & 8th Grades

Public Expenditure on Education (% of GDP)[9]	Net Enrollment Ratio in Education (% of Relevant Group)[10]		Primary Pupil-Teacher Ratio[11]	Country
	Primary	Secondary		
–	95	66	25	Algeria
–	82	86	21	Armenia
5	96	86	–	Australia
5	97	–	12	Austria
–	96	90	–	Bahrain
–	–	–	–	Bosnia and Herzegovina
9	86	61	25	Botswana
3	93	89	16	Bulgaria
4	99	95	17	[12] Chinese Taipei
5	88	65	28	Colombia
6	100	94	18	Cyprus
4	93	–	16	Czech Republic
8	96	91	–	Denmark
–	94	83	26	Egypt
3	94	54	40	El Salvador
5	99	95	22	England
3	89	79	15	Georgia
5	–	–	14	Germany
5	66	38	32	Ghana
4	93	78	18	Hong Kong SAR
5	89	90	10	Hungary
1	95	57	20	Indonesia
5	94	77	19	Iran, Islamic Rep. of
7	97	89	13	Israel
5	99	92	10	Italy
4	100	100	19	Japan
–	91	79	20	Jordan
3	90	86	17	Kazakhstan
5	98	94	28	Korea, Rep. of
4	83	–	10	Kuwait
5	90	–	12	Latvia
3	82	73	14	Lebanon
5	88	94	14	Lithuania
6	99	72	17	Malaysia
–	86	84	11	Malta
5	91	82	33	Mongolia
7	88	35	27	Morocco
5	98	87	10	Netherlands
7	99	–	16	New Zealand
8	98	96	11	Norway
5	74	77	14	Oman
11	80	95	25	Palestinian Nat'l Auth.
2	96	90	11	Qatar
3	91	81	17	Romania
4	92	–	17	Russian Federation
7	93	60	15	Saudi Arabia
5	100	100	16	Scotland
–	96	–	–	Serbia
–	–	–	24	Singapore
4	92	–	18	Slovak Republic
6	96	91	15	Slovenia
7	97	99	10	Sweden
–	92	63	–	Syrian Arab Republic
4	94	71	18	Thailand
7	97	–	20	Tunisia
4	90	66	–	Turkey
6	90	84	17	Ukraine
6	92	88	14	United States
–	75	37	–	Yemen

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2007

All data taken from the *2008 World Development Indicators* (World Bank, 2008) unless otherwise noted.

1 Includes all residents regardless of legal status or citizenship except refugees not permanently settled in the country of asylum as they are generally considered to be part of their country of origin (pp. 40–43). Data for Palestinian National Authority, England, and Scotland provided by the National Research Coordinator (NRC).

2 Area is the total surface area in square kilometers, excluding the area under inland water bodies and national claims to the continental shelf and exclusive economic zones (pp. 130–133). Data for Palestinian National Authority, England, and Scotland provided by the NRC.

3 Mid-year population is divided by land area in square kilometers (pp. 14–17). Data for Palestinian National Authority, England, and Scotland provided by the NRC.

4 Urban population is the mid-year population of areas defined as urban in each country and reported to the United Nations. It is measured here as the percentage of the total population (pp. 170–173). Data for Palestinian National Authority, England, and Scotland provided by the NRC.

5 Number of years a newborn infant would live if prevailing patterns of mortality at its birth were to stay the same throughout its life (pp. 118–121). Data for Palestinian National Authority, England, and Scotland provided by the NRC.

6 Infant mortality rate is the number of deaths of infants under 1 year of age, per 1,000 live births in the same year (118–121). Data for Palestinian National Authority, England, and Scotland provided by the NRC.

7 GNI per capita in U.S. dollars is converted using the World Bank Atlas method (pp. 14–17). Data for Palestinian National Authority provided by the NRC. Figures for England and Scotland are for the whole region of the United Kingdom.

8 An international dollar has the same purchasing power over GNI as a U.S. dollar in the United States (pp. 14–17). Figures for England and Scotland are for the whole region of the United Kingdom.

9 Current and capital public expenditure on primary, secondary, and tertiary education expressed as a percentage of GDP (pp. 76–79). Data for Palestinian National Authority provided by the NRC. Figures for England and Scotland are for the whole region of the United Kingdom.

10 Ratio of the children of official school age who are enrolled in school to the population of the corresponding official school age, based on the International Standard Classification of Education 1997 (pp. 80–83). Data also provided by the Global Education Digest 2007, UNESCO Institute for Statistics (pp. 81-89, 101-109). Figures for England are for the whole region of the United Kingdom. Figures for Scotland provided by the NRC.

11 Primary pupil-teacher ratio is the number of pupils enrolled in primary school divided by the number of primary school teachers (regardless of their assignment (pp. 76–79). Data for England and Scotland provided by the NRC.

12 Data for Chinese Taipei provided by the NRC.

A dash (–) indicates comparable data are not available.

The economic indicators in Exhibit 3, such as the data for gross national income per capita, reveal great disparity in the economic resources available, and also that different policies exist about the percentage of funds that is spent on education. Economically, the TIMSS 2007 countries ranged from Kuwait, Norway, Singapore, and the United States with relatively high gross national incomes per capita (in U.S. dollars adjusted for purchasing power parity) to Egypt, Georgia, Ghana, Indonesia, Jordan, Mongolia, Morocco, and Syria with relatively low gross national incomes per capita. Although a number of countries had 95 percent or more of their primary and secondary students enrolled in school, there were differences in enrollments rates, especially at the secondary level.

Years of Schooling

The individual chapters contain considerable information about the structure and levels of primary and secondary education in each of the countries, provinces, or states. However, Exhibit 4 summarizes the years of schooling that are provided and compulsory in each country from preprimary through secondary schooling. Although preprimary schooling was not compulsory in the majority of countries, it was provided in all countries, including all benchmarking participants.

Primary and secondary schooling was compulsory in every country and benchmarking participant except one (Oman). There was variation in the ages at which students were supposed to start school, but it generally was 6 or 7. For most TIMSS 2007 participants, school was compulsory through age 15 or 16. The number of compulsory school grades ranged from 0 to 12 grades, although the most frequent number was 9. In general, most TIMSS 2007 participants provided primary and secondary schooling through grade 12 and in some instances beyond. For example, Austria, Hong Kong SAR, Italy, Norway, Slovak Republic, and Tunisia all provided schooling through grade 13.

Exhibit 4 Years of Compulsory Schooling

TIMSS2007 Mathematics & Science 4th & 8th Grades

Country	Preprimary Compulsory Schooling		Preprimary Schooling Provided		Primary and Secondary Compulsory Schooling		Grades Provided for Primary and Secondary Schooling
	Ages	Grades	Ages	Grades	Ages	Grades	
Algeria	not compulsory	not compulsory	5–6; children must be 5 years old by December 31st	preschool	6–16; children must be 6 years old by December 31st of the academic year in which they enroll	1–9	1–9
Armenia	not compulsory	not compulsory	3–6; no age of entry regulation	kindergarten	6–14; children must be 6 years old by the end of June to begin in September	1–9	1–12
Australia	not compulsory	not compulsory	3–5; age of entry varies by state and preprimary level	prepatory, reception, kindergarten, transition, preprimary	6–16; children must have started school by 6 years old	grade 1 – year 10	grade 1– year 12
Austria	not compulsory	not compulsory	0–6; age of entry varies by Bundesland; generally children must be 3 years old to enter nursery school	creche, nursery school	6–15; children must be 6 by September 1st, or upon special request, by March 1st the following year	1–9	1–13
Bahrain	not compulsory	not compulsory	3–5	no grades	6–17; children must be 6 by the end of December	1–9	1–12
Bosnia and Herzegovina	not compulsory	not compulsory	0 – 5 or 6; no age of entry regulation	no grades	6–15; children must be 6 by December 31st	1–8 or 1–9	1–12
Botswana	not compulsory	not compulsory	4–6; no formal preprimary education system	no grades	6–15; children must be 6 by June, although in rural or remote areas the entry age is flexible	Primary grades 1–7; secondary grades 8–10	1–7 (standards 1–7) and 8–12 (forms 1–5)
Bulgaria	5–6	kindergarten	3–6; children must be 3 years old by September 15th	preprimary	6–16; children must be 7 years old in the calendar year, or 6 years old with parent/ guardian permission	1–11	1–12
Chinese Taipei	not compulsory	not compulsory	4–6; children must be 4 years old by the beginning of the academic year	Bottom class in nursery school (age 3), middle class in kindergarten, and top class in kindergarten	6–15; children must be 6 years old by September 1st	1–9	1–12
Colombia	5; no age of entry regulation	3rd preprimary	3–5	1st–3rd preprimary	6–15; children must be 6 years old	1–9	1–11
Cyprus	4 years, 8 months – 5 years, 8 months	preprimary	3 – 5 years, 8 months; students must be at least 4 years, 8 months old by September 1st	preprimary & kindergarten	5 years, 8 months – 15 ; the student must be 5 years, 8 months old by September 1st	1–9	1–12
Czech Republic	not compulsory	not compulsory	3–6; no age of entry regulation	1–3	6–15; children must be 6 years old by September 1st	1–9	1 – 12 or 13
Denmark	not compulsory	not compulsory	6 months – 5 or 6 years	nursery, integrated institutions, kindergarten, preschool	7 – 16 or 17; children must be 7 years old in the calendar year to begin August 1st	1–9	1–12
Egypt	not compulsory	not compulsory	4–6; children must be 4 years old by September 1st	kindergarten grade 1– kindergarten grade 2	6–15; children must be 6 years old by October 1st	1–9	1–12
El Salvador	not compulsory	not compulsory	0–6; no age of entry regulation	initial, kindergarten–3	7–15; children must be 7 years old	1–9	1–12
England	not compulsory	not compulsory	3–5; no age of entry regulation	pre–grade kindergarten	5–16; children must begin school at the start of the term following their 5th birthday	K – 10	K – 12
Georgia	not compulsory	not compulsory	1–5; no age of entry regulation	nurseries and kindergartens	6–15; children must be 6 years old by the end of December	1–9	1–12

Data provided by National Research Coordinators.

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2007

Exhibit 4 Years of Compulsory Schooling (Continued)

TIMSS2007 Mathematics & Science 4th & 8th Grades

Country	Preprimary Compulsory Schooling		Preprimary Schooling Provided		Primary and Secondary Compulsory Schooling		Grades Provided for Primary and Secondary Schooling
	Ages	Grades	Ages	Grades	Ages	Grades	
Germany	not compulsory	not compulsory	3–6; no age of entry regulation	kindergarten, preschool	6 – 16; children must be 6 years old by June 30th, or upon special request, by December 31st of that year	1–10	1–12 or 13
Ghana	4–6; children must turn 4 years old during the calendar year	kindergarten 1 and 2	4–6	kindergarten 1 and 2	6–15; children must be 6 years old in the calendar year to begin in September	1–9	1–12
Hong Kong SAR	not compulsory	not compulsory	2–6; children must be 2 years, 8 months old by September 1st	childcare and kindergarten levels K1–K3	5 years, 8 months–15; children must be 5 years, 8 months old in September	1–9	1–13
Hungary	5; children must be 5 years old in the calendar year	1 year of kindergarten is compulsory	3–7	no grades	6–18; children must be 6 years old by May 31st or upon special request, by December 31st to begin school in September	1–11	1–13
Indonesia	not compulsory	not compulsory	4–6; children must be 4 years old by mid–July	playgroup, kindergarten A, kindergarten B	7–15; children may enter at 6 years old, but must enter at 7 years old	1–9	1–12
Iran, Islamic Rep. of	not compulsory	not compulsory	3–5; children must be 5 years old by September 20th for kindergarten	pre–kindergarten and kindergarten	6–14; children must be 6 years old by September 20th to start school on September 21st of the same year	1–8	1–12
Israel	3–6	kindergarten	3–6; children must be 3 years old; each year there is an announcement specifying the birth dates that are relevant to the requirement	kindergarten	6–16; children must be 6 years old; each year there is an announcement specifying the birth dates that are relevant to the requirement	1–10	1–12
Italy	not compulsory	not compulsory	3–5; students must be 3 years old by April 30th of the corresponding school year	preprimary education	6–16; children must be 6 years old by December 31st, or by March 31st the following year with an examination	1–10	1–15
Japan	not compulsory	not compulsory	3–5	kindergartens and nursery schools	6–15; children must be 6 years old by April 1st	1–9	1–12
Jordan	not compulsory	not compulsory	3 years, 8 months–5 years, 8 months; children must be 3 years, 8 months old by September 1st for kindergarten 1; children must be 4 years, 8 months by September 1st for kindergarten 2	kindergarten 1 and 2	5 years, 8 months – 16; children must be 5 years, 8 months old by September 1st	1–10	1–12
Kazakhstan	5–6	preparatory group (last year of preprimary)	1–6; children must be 1 year old by September 1st	early age group, younger groups 1–2, average group, senior or preparatory group	6–17; children must be 6 years old by the end of August to begin in September	1–11	1–11
Korea, Rep. of	not compulsory	not compulsory	3–5; no age of entry regulation	kindergarten	6–14; children must be 6 years old, or 5 years old based on the guardian's decision	1–9	1–12
Kuwait	not compulsory	not compulsory	4–6; children must be 4 years old between September 1st – March 15th	kindergarten	5.5 – 10; children must be 5.5 years old by September 1st	1–5	1–12

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2007

Exhibit 4 Years of Compulsory Schooling (Continued)

TIMSS2007 Mathematics & Science 4th & 8th Grades

Country	Preprimary Compulsory Schooling		Preprimary Schooling Provided		Primary and Secondary Compulsory Schooling		Grades Provided for Primary and Secondary Schooling
	Ages	Grades	Ages	Grades	Ages	Grades	
Latvia	5–6	no grades	2–6	no grades	7– 15 or 16; children must be 7 years old during the calendar year	1–9	1–12
Lebanon	5–6	kindergarten	5–6	kindergarten	6–12; children must be 6 years old	1–6	1–12
Lithuania	not compulsory	not compulsory	1–6; no age of entry regulation	kindergarten	7–16; children may begin school when they are 6 years old, and are required when they are 7	1–10	1–12, and Gymnasiums (advanced 9–12)
Malaysia	not compulsory	not compulsory	5–6	preschool	6–11; children begin school during the calendar year of their 7th birthday	1–6	1–11
Malta	not compulsory	not compulsory	3–4; children must be 3 years old either by the end of December or by the end of April for October or February entry respectively	kindergarten 1 and 2	5–16; children must be 5 years old by the end of December	year 1 – form 5 (grades 1–11)	year 1 to form 6
Mongolia	6–7	primary class, secondary class, senior class, preprimary	3–7; children must be 3 years old	primary class, secondary class, senior class, preprimary	7–16; children must be 7 years old, or in special cases, 8 years old	1–9	1–11
Morocco	not compulsory	not compulsory	3–6	no grades	6–15; children must be 6 years old in September	1–9	1–11
Netherlands	5–6; children begin school on the first day of the month that follows the month of their 5th birthday	kindergarten (grade 2)	4–6	kindergarten (grades 1–2)	6 – 16 or 18	1–10, 11, or 12 (depending on track)	1–12
New Zealand	not compulsory	not compulsory	0–6, children usually begin primary school on the closest school day after their 5th birthday	no grades	6–16; children must be in school by the time they are 6 years old	1–11 (years 2–12)	K–12 (years 1–13)
Norway	not compulsory	not compulsory	0–5 or 6	no grades	6–16; children begin school during the calendar year of their 6th birthday	1–10	1–13
Oman	not compulsory	not compulsory	3.5–6; children must be 3.5 years old by September 1st	kindergarten grade 1– kindergarten grade 2	not compulsory	not compulsory	1–12
Palestinian Nat'l Auth.	not compulsory	not compulsory	3 years, 8 months – 5 years, 7 months; children must be 3 years and 8 months old	kindergarten grade 1– kindergarten grade 2	5 years, 8 months – 16; children must be 5 years, 8 months old by September 1st	1–10	1–12
Qatar	not compulsory	not compulsory	4–6; children must be age 4 by September 1st	kindergarten grade 1– kindergarten grade 3	6–15; children must be 6 years old by the end of September	1–9	1–12
Romania	5–6; no age of entry regulation	preparatory grade (last year of preprimary)	3–6	lower, middle, upper, and preparatory grade	6 or 7 – 16; there is no specific date regulation about the age of entry	1–10	1–12 or 13
Russian Federation	not compulsory	not compulsory	3–6; no age of entry regulation	preprimary	6.5–16; children must be 6.5 years old	1–9	1–11
Saudi Arabia	–	–	–	–	Children must be 6 years old, or must turn 6 within 90 days of starting school	–	–

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2007

Exhibit 4 Years of Compulsory Schooling (Continued)

TIMSS2007 Mathematics & Science 4th & 8th Grades

Country	Preprimary Compulsory Schooling		Preprimary Schooling Provided		Primary and Secondary Compulsory Schooling		Grades Provided for Primary and Secondary Schooling
	Ages	Grades	Ages	Grades	Ages	Grades	
Scotland	not compulsory	not compulsory	3–5; entrance age requirement varies by birth date	pre–grade kindergarten	5–16; children can begin school between the ages of 4.5 and 6; those with a March–August birth date must start in the August following their 5th birthday; children with a September–February birth date may defer entry until the following year	K–10	K–12 (primary 1–7 and secondary 1–6)
Serbia	6.5 – 7.5; children may enroll at the age of 5.5 years old	preschool group	1 – 7.5; children must be 5.5 for the prepatory preschool program by September 1st	preschool group	7.5 – 14; children must be at least 6.5 years old and no older than 7.5 years old by September 1st to begin school in September	1–8	primary grades 1–8 and secondary grades 1–4
Singapore	not compulsory	not compulsory	3–6; children must be 3 years old by January 1st	nursery, kindergarten 1–2	6–12; children must be 6 years old by January 1st of the year of admission	1–6	1–10
Slovak Republic	not compulsory	not compulsory	2–6; generally, children must be 3 years old, but exceptions are made by the directors of preprimary schools	kindergarten	6–16; children must be 6 years old by the end of August to begin school in September	1–9 or 10	1–13
Slovenia	not compulsory	not compulsory	1–6; children must be 11–12 months old	kindergarten	6–15; children must be 6 years old by December 31st	1–9	1–13
Sweden	not compulsory	not compulsory	1–5 and 6; no age of entry regulation	preschool and preschool class	7 –15 or 16; children must begin during the calendar year they turn 7; upon parental request, children may start school the year they turn 6 or 8	1–9	1–12
Syrian Arab Republic	not compulsory	not compulsory	3–5	kindergarten	6–14; children must be 5 years, 9 months old by January	1–4 (First cycle); 5–9 (Second cycle)	first cycle (grades 1–4), second cycle (grades 5–9), secondary stage (grades 10–12)
Thailand	not compulsory	not compulsory	3–5; children must be 3 or 4 (depending on the school type) either in the calendar year or by May 16th	preprimary grades 1–2 or 1–3	6 or 7 – 15 or 16; children must be 6 years old by May 16th	primary grades 1–6 and lower secondary grades 1–3	primary grades 1–6, lower secondary grades 1–3, and higher secondary grades 1–3
Tunisia	not compulsory	not compulsory	5–6; children must be age 5 during the calendar year	preschool	6–16; children must be 6 years old by the end of December of the year in which they enter school, or by the end of March if there are vacancies	1–9	1–13
Turkey	not compulsory	not compulsory	3– 6; children must be 3 years old by the end of September	kindergarten or application classrooms	6–14; children must be 6 years old by the end of September	1–8	1–12
Ukraine	6; children must be 6 years old by September 1st	1–4	6	1–4	7–14; children begin school during the calendar year of their 7th birthday	1–9	1–12
United States	not compulsory	not compulsory	ages 3–5; entry ages vary by state and locality	nursery school, pre–kindergarten, kindergarten	6 – 16 or 17 or 18, depending on state laws (the U.S. public generally considers kindergarten as part of primary schooling)	not compulsory by grade; age, as set by the states, is the determining factor	1–12
Yemen	not compulsory	not compulsory	3–6; children must be 3 years old by October 1st	preschool	6–17; children must be 6 years old by October 1st of the related school year	1–9	1–12

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2007

Exhibit 4 Years of Compulsory Schooling (Continued)

TIMSS2007 Mathematics & Science 4th & 8th Grades

Country	Preprimary Compulsory Schooling		Preprimary Schooling Provided		Primary and Secondary Compulsory Schooling		Grades Provided for Primary and Secondary Schooling
	Ages	Grades	Ages	Grades	Ages	Grades	
Benchmarking Participants							
Alberta, Canada	not compulsory	not compulsory	5; no age of entry regulation	kindergarten	6–16; children must be 6 years old by June 1st to begin school the following September	1–12	1–12
Basque Country, Spain	not compulsory	not compulsory	0–5	infant school and preschool	6–16; children begin school during the calendar year of their 6th birthday	primary grades 1–6 and secondary grades 1–4	primary grades 1–6 , secondary grades 1–4, upper secondary, vocational
British Columbia, Canada	5–6; children must be 5 years old by December 31st	kindergarten	5–6	kindergarten	6–16; children must be 6 years old by December 31st	compulsory enrollment is determined by age, not grade	1–12
Dubai, UAE	not compulsory	not compulsory	3.5 – 5.5; children must be 3.5 by October 1st	kindergarten	5.5 – 13.5; children must be 5.5 by October 1st	1–9	1–12
Massachusetts, US	not compulsory	not compulsory	2 years, 9 months – 6; children must be 2 years, 9 months old	preschool, kindergarten	6–16; children must be 6 years old during the calendar year (or younger if the school committee agrees) to start in September	compulsory enrollment is determined by age, not grade	1–12
Minnesota, US	not compulsory	not compulsory	3–6; children must be 3 years old by September 1st	preschool, kindergarten	7–16; children must be in school by the time they are 7 years old	1–12	1–12
Ontario, Canada	not compulsory	not compulsory	4–5; children must be 4 or 5 years old by December 31st	junior kindergarten and senior kindergarten	6–18; children who are 6 years old by the first school day in September are required to begin, but any student who is 6 by December 31st may also begin in September	1–12	1–12
Quebec, Canada	not compulsory	not compulsory	4–5; children must be 4 or 5 by October 1st	preschool and kindergarten	6–16; children must be 6 years old by October 1st to begin in September	compulsory enrollment is determined by age, not grade	primary: cycle 1–3 (grades 1–6); secondary: cycle 1–2 (secondary 1–5)

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2007

Structural Characteristics of the Mathematics Curriculum

The results in Exhibit 5 show that most of the TIMSS 2007 countries reported having a national mathematics curriculum, including 46 at the fourth grade and 49 at the eighth grade.

Curriculum development appears to be an ongoing activity in many countries. At the time of the TIMSS 2007 testing, the official mathematics curriculum in 26 of the countries had been in place for 5 years or less, and of those curricula, 11 were under revision at the fourth grade. At the eighth grade, 24 countries had official curricula in place 5 years or less and of those, 13 were under revision at the time of the assessment. Of the 23 countries with a fourth grade mathematics curriculum that had been in place for more than 5 years, 16 were revising it at the time of TIMSS 2007. At the eighth grade, 22 out of 28 countries with a mathematics curriculum in place for more than 5 years were revising them.

Of the benchmarking participants at the fourth grade, only two of the curricula had been in place for 5 years or less. Of the five benchmarking participants with a curriculum older than 5 years, all five of the curricula were under revision. At the eighth grade, three benchmarking participants had official curricula that were in place for 5 years or less, and of the four with a curriculum older than 5 years, all four of the curricula were under revision.

There was considerable diversity regarding the structure of the curriculum. The grade-to-grade (year-to-year) structure ranged from one curriculum encompassing a range of grades (e.g., grades 1–6) to a separate curriculum for every grade. However, a range of three grades or more was the most common structure.

Public examinations with consequences for individual students are another common feature of many countries' education systems. Although public examinations can provide information of interest to national and regional policy-makers, their main purpose is to make decisions about individual students, such as promotion from one grade to another, entry to a higher school system, or graduation from secondary school. Among all TIMSS 2007 participants, all but seven countries and one benchmarking participant reported having public examinations in mathematics at one or more grades, most commonly at the twelfth grade. Student examinations with consequences in mathematics at this level were given by 34 countries and 4 benchmarking participants.

Structural Characteristics of the Science Curriculum

As was the case for mathematics, the results in Exhibit 6 show that most of the TIMSS 2007 countries reported having a national science curriculum, including 47 at the fourth grade and 51 at the eighth grade.

At the time of the TIMSS 2007 testing, the official science curriculum had been in place for 5 years or less in 25 of the countries at fourth grade, and 21 at eighth grade. Of those, 10 at each grade were under revision. Of the 25 countries with a fourth grade science curriculum that had been in place for more than 5 years, 17 were revising it at the time of TIMSS 2007. At the eighth grade, 24 out of 33 countries with a science curriculum in place for more than 5 years were revising their curriculum.

Of the benchmarking participants at the fourth and eighth grades, three of the curricula were in place for 5 years or less. Of the benchmarking participants with a curriculum older than 5 years, four of the curricula at each grade level were under revision.

Also, similar to mathematics, the grade-to-grade (year-to-year) structure ranged from one curriculum encompassing a range of grades (e.g., grades 1–6) to a separate curriculum for every grade. Likewise, a range of three grades or more was the most common structure.

Public examinations with consequences are also frequently used in science to make decisions about individual students. Among all TIMSS 2007 participants, all but ten countries and two benchmarking participants reported having public examinations in science at one or more grades, most commonly at the twelfth grade. Student examinations with consequences in science were given at the twelfth grade by 34 countries and 4 benchmarking participants.

Components of the Curriculum for Mathematics and Science

The components included in the curriculum documents for mathematics and science varied by country, ranging from containing only the goals and objectives, to describing the percentage of students expected to reach defined goals. Exhibit 7 shows the various components described by the curriculum for mathematics and science. In both mathematics and science and at both grades, all but one of the TIMSS 2007 participants (Bahrain) reported that their curricula described goals and objectives. At the fourth grade, 39 of the countries described processes or methods used in both their mathematics and science curricula. At the eighth grade, 45 described this component for mathematics and 43 for science. Among benchmarking participants at both grade levels, 4 participants described processes or methods in their mathematics curriculum and 7 in their science curriculum.

The number of countries with curricula that described materials to use in instruction was lower than the number describing the other components, 31 for both mathematics and science at the fourth grade. At the eighth grade, the numbers were 38 for mathematics and 35 for science. For mathematics at both grades, only two out of eight benchmarking participants reported that their curriculum described materials, while in science only one described materials at the fourth grade and two at the eighth grade. The final component, the percentage of students reaching defined goals, was rarely described in the curricula. At both grades and in both subjects, fewer than 10 countries and no benchmarking participants included this component in their curriculum.

Exhibit 5 Structural Characteristics of the Mathematics Curriculum

TIMSS2007 Mathematics 4th Grade

Country	National Curriculum	Year Curriculum Introduced	Curriculum Under Revision	Curriculum Stucture Grade-to-Grade (Year-to-Year)	Examinations with Consequences for Individual Students	Grades with Examinations
Algeria	●	2004	●	1–6	●	5, 9
Armenia	●	2006	●	1–4	●	9, 11
Australia	○	–	●	varies by state	●	12
Austria	●	2003	●	1–2,3,4	●	12, 13
Bosnia and Herzegovina	○	2004	●	1–3, 4–6	●	–
Botswana	●	2002	○	1–4	●	4,7,10,12
Bulgaria	●	2005	○	1–4	●	7–8,12–13
Chinese Taipei	●	2001	○	1–3,4–5	●	9
Colombia	○	2003	○	K–3, 4–6	●	11
Cyprus	●	1994	●	1–6	●	7–12
Czech Republic	●	1996	●	1–5	○	–
Denmark	●	2003	○	1–3,4–6	○	–
El Salvador	●	1994	●	1–3,4–6	●	11–12
England	●	2000	●	K–1, 2–5	●	1,5,8,10,12
Georgia	●	1997	●	1–6	○	–
[1] Germany	○	2003	●	1–4	●	9/10,12/13
Ghana	●	2007	○	1–6	●	9,12
Hong Kong SAR	●	2002	○	1–6	●	11,13
Hungary	●	2007	○	1–4	●	12
Iran, Islamic Rep. of	○	–	●	1–5	●	5,7,8,11,12
Israel	●	2005	○	1,2,3,4,5,6	●	12
Italy	●	2004	●	1–5	●	–
Japan	●	2002	○	1–6	○	–
Jordan	●	2005	○	1–10	●	12
Kazakhstan	●	2003	●	1–4	●	4–11
Korea, Rep. of	●	2001	●	1–6	●	12
Kuwait	●	2005	○	1–5	●	5–12
Latvia	●	2006	○	1–3,4–6	●	6,9,12
Lithuania	●	2003	●	1–2,3–4	●	10,12
Malaysia	●	2003	●	1–6	●	6,9,11
Malta	●	2002	○	1–6	●	4–11
Mongolia	●	2004	○	1–5	●	1–12
Morocco	●	2003	○	1–2,3–6	●	6,9,11,12
Netherlands	●	2006	○	–	●	10,11 or 12
New Zealand	●	1993	●	K–2,2–4,4–6	●	10–12
Norway	●	2006	○	1–2,3–4	●	10
Oman	●	1999	●	1–4	●	12
Palestinian Nat'l Auth.	●	2003	●	1–4	●	4–12
Qatar	●	1990	●	1–3,4–5	●	12
Romania	●	1998	●	1–4	●	8,12
Russian Federation	●	1998	●	1–4	●	9,11
Scotland	●	1991	●	K–8	●	10,11,12
Serbia	●	1991	○	1–4	●	8
Singapore	●	2001	●	1–6	●	6,10,12
Slovak Republic	●	1995	●	1–4	●	9
Slovenia	●	1999	●	1–3,4–6	●	12
Sweden	●	2000	●	1–5	○	–
Tunisia	●	2004	○	1–2,3–4	●	4,6,9,13
Turkey	●	2005	●	1–8	●	8
Ukraine	●	2006	○	1–4	●	4,9,11
United States	○	–	●	varies by state	○	–
Yemen	●	2000	○	1–6	●	9,12
Benchmarking Participants						
Alberta, Canada	○	1997	●	1,2,3,4,5,6	●	3,6,9,12
Basque Country, Spain	●	1992	●	1–6	●	–
British Columbia, Canada	○	1995	●	K–1,2–3,4	●	10,12
Dubai, UAE	●	2005	●	1–3,4–5	●	1–12
Massachusetts, US	○	2000	●	Pre–K–K,1–2,3,3–4	●	3–8,10
Minnesota, US	○	–	–	K,1,2,3,4	●	12
Ontario, Canada	○	2005	○	1,2,3,4	○	–
Quebec, Canada	○	2000	●	1–2,3–4,5–6	●	10,11

● Yes ○ No

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2007

Data provided by National Research Coordinators.

1 For Germany, the grade-to-grade structure varies by federal states with binding character. All states offer grades 1–4, Berlin 1–4 and 1–6, Brandenburg 1–6.

A dash (–) indicates comparable data are not available.

Exhibit 5 Structural Characteristics of the Mathematics Curriculum (Continued)

TIMSS2007 Mathematics 8th Grade

Country	National Curriculum	Year Curriculum Introduced	Curriculum Under Revision	Curriculum Stucture Grade-to-Grade (Year-to-Year)	Examinations with Consequences for Individual Students	Grades with Examinations
Algeria	●	2004	●	7–8	●	5, 9
Armenia	●	2006	●	5–9,10–12	●	9, 11
Australia	○	–	●	7–8	●	12
Austria	●	2000	○	5,6,7,8	●	12,13
Bahrain	○	1985	●	–	●	9,12
Bosnia and Herzegovina	○	2004	●	7–9	●	–
Botswana	●	1996	●	5–7,8–10	●	4,7,10,12
Bulgaria	●	1994	●	5–8	●	7–8,12–13
Chinese Taipei	●	2003	●	8–9	●	9
Colombia	○	2003	○	7–9	●	11
Cyprus	●	1997	○	7–9	●	7–12
Czech Republic	●	1996	●	6–9	○	–
Egypt	●	–	○	7–9	●	6,9,12
El Salvador	●	1996	●	7–9	●	11–12
England	●	2000	●	6–8	●	1,5,8,10,12
Georgia	●	2005	●	7–9	○	–
Ghana	●	2007	○	7–9	●	9,12
Hong Kong SAR	●	2001	○	7–9	●	11,13
Hungary	●	2007	○	5–6,7–8	●	12
Indonesia	○	2004	●	7–9	●	–
Iran, Islamic Rep. of	○	–	●	6–8	●	5,7,8,11,12
Israel	●	2004	●	7–9	●	10–12
Italy	●	2004	●	6–8	●	8,13
Japan	●	2002	○	7–9	○	–
Jordan	●	2005	○	1–10	●	12
Kazakhstan	●	2003	●	5–9	●	4–11
Korea, Rep. of	●	2001	●	7–9	●	12
Kuwait	●	2005	○	1–5,6–9	●	5–12
Lebanon	●	1998	●	7–9	●	9,12
Lithuania	●	2003	●	5–6,7–8	●	10,12
Malaysia	●	2003	○	7–9	●	6,9,11
Malta	●	2000	●	7–11	●	4–11
Mongolia	●	2004	○	6–9	●	1–12
Morocco	●	2006	○	7–9	●	6,9,11,12
Netherlands	●	2006	○	–	●	10,11 or 12
New Zealand	●	1993	●	6–8,8–10	●	10–12
Norway	●	2006	○	8–10	●	10
Oman	●	2004	●	5–10	●	12
Palestinian Nat'l Auth.	●	2003	●	1–4,5–10,11–12	●	4–12
Qatar	●	1990	●	7–9	●	12
Romania	●	1998	●	5–8	●	8,12
Russian Federation	●	1998	●	5–9	●	9,11
Saudi Arabia	●	1988	●	7–9	●	–
Scotland	●	1991	●	K–8	●	10,11,12
Serbia	●	2006	○	1–8	●	8
Singapore	●	2001	●	7–8	●	6,10,12
Slovak Republic	●	1997	●	5–9	●	9
Slovenia	●	1999	●	7–9	●	12
Sweden	●	2000	○	6–9	○	–
Syrian Arab Republic	●	2003, 2007	●	4–9	●	6,9,10,12
Thailand	●	2001	●	7–9	●	6,9,12
Tunisia	●	1997	●	7,8,9	●	4,6,9,13
Turkey	●	1998	●	1–8	●	8
Ukraine	●	2001	●	5–6,7–9	●	4,9,11
United States	○	–	●	varies by state	○	–
Yemen	●	2001	○	7–9	●	9,12
Benchmarking Participants						
Alberta, Canada	○	1997	●	7,8,9	●	3,6,9,12
Basque Country, Spain	●	1992	●	7–10	●	–
British Columbia, Canada	○	2001	●	5,6,7,8	●	10,12
Dubai, UAE	●	2007	●	6–7,8–9	●	1–12
Massachusetts, US	○	2000	●	5,5–6,7,7–8	●	3–8,10
Minnesota, US	○	–	●	5,6,7,8	●	12
Ontario, Canada	○	2005	○	5,6,7,8	○	–
Quebec, Canada	○	2005	○	7–8	●	10,11

● Yes ○ No

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2007

Data provided by National Research Coordinators.
A dash (–) indicates comparable data are not available.

Exhibit 6 Structural Characteristics of the Science Curriculum

TIMSS2007 Science 4th Grade

Country	National Curriculum	Year Curriculum Introduced	Curriculum Under Revision	Curriculum Stucture Grade-to-Grade (Year-to-Year)	Examinations with Consequences for Individual Students	Grades with Examinations
Algeria	●	2003	●	1–6	●	11
Armenia	●	2006	●	1–4	●	8,10
Australia	○	–	●	varies by state	●	12
Austria	●	2006	●	1–2,3,4	●	12,13
Bosnia and Herzegovina	○	2004	●	1–3, 4–6	●	8,12
Botswana	●	2002	○	1–4	●	7,10,12
Bulgaria	●	2005	○	3–4	●	8,12–13
Chinese Taipei	●	2005	○	1–2,3–4	●	9
Colombia	○	2004	○	K–3,4–6	●	11
Cyprus	●	1996	○	1–6	●	7–12
Czech Republic	●	1996	●	1–5	○	–
Denmark	●	2003	○	1–2,3–4	○	–
El Salvador	●	1996	●	1–3,4–6	●	11–12
England	●	1999	●	K–1, 2–5	●	5,8,10,12
Georgia	●	1997	●	3–6	○	–
1 Germany	○	2003	○	1–4	●	9/10,12/13
Ghana	●	2007	○	1–6	●	9,12
Hong Kong SAR	●	2002	○	3–6	●	11,13
Hungary	●	2007	○	1–4	●	12
Iran, Islamic Rep. of	●	1994	○	1–5	●	5,8,11,12
Israel	●	1998	○	1,2,3–4,5–6	●	12
Italy	●	2004	●	1–5	●	8,13
Japan	●	2002	●	3–6	●	9,12
Jordan	●	2005	○	1–10	●	12
Kazakhstan	●	2003	●	1–4	●	4–11
Korea, Rep. of	●	2001	●	1–6	●	12
Kuwait	●	1980	●	1–5	●	5–12
Latvia	●	2006	○	1–3,4–6	●	6,9,12
Lithuania	●	2003	●	1–2,3–4	●	12
Malaysia	●	2003	●	1–6	●	6,9,11
Malta	●	2001	○	1–6	●	4–11
Mongolia	●	2004	○	–	●	9,11
Morocco	●	2003	○	1–2,3–6	●	6,9,11,12
Netherlands	●	2006	○	–	●	10,11, or 12
New Zealand	●	1995	●	K–2,2–4,4–6	●	10–12
Norway	●	2006	○	1–2,3–4	●	10,11–13
Oman	●	1999	●	1–4	●	12
Palestinian Nat'l Auth.	●	2003	●	1–4	●	4–12
Qatar	●	1990	●	1–4	●	12
Romania	●	1998	●	1–4	●	12
Russian Federation	●	1998	●	1–4	●	9,11
Scotland	●	2000	●	K–8	●	10–12
Serbia	●	1990	●	1–4	○	–
Singapore	●	2001	●	3–6	●	6,10,12
Slovak Republic	●	1995	●	1–4	○	–
Slovenia	●	1999	●	1–3,4–6	●	12
Sweden	●	2000	○	1–5	○	–
Tunisia	●	2004	○	1–2,3–4,5–6	●	4,6,9,13
Turkey	●	2005	●	1–3,4–5	●	8
Ukraine	●	2006	○	1–4	●	9,11
United States	○	–	●	varies by state	○	–
Yemen	●	2000	○	1–6	●	9,12
Benchmarking Participants						
Alberta, Canada	○	1996	●	1,2,3,4	●	6,9,12
Basque Country, Spain	●	1992	●	3–6	●	12
British Columbia, Canada	○	2005	○	K,1,2,3,4	●	10,12
Dubai, UAE	●	2004	●	1–3,4–5	●	1–12
Massachusetts, US	○	2001	○	Pre–K–2,3–5	●	5,8,9–10
Minnesota, US	○	2004	○	K–2, 3–5	○	–
Ontario, Canada	○	1998	●	1,2,3,4	○	–
Quebec, Canada	○	2000	●	1–6	●	10

● Yes ○ No

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2007

Data provided by National Research Coordinators.

1 For Germany, the grade-to-grade structure varies by federal states with binding character. All states offer grades 1–4, Berlin 1–4 and 1–6, Brandenburg 1–6.

A dash (–) indicates comparable data are not available.

Exhibit 6 Structural Characteristics of the Science Curriculum (Continued)

TIMSS2007 Science 8th Grade

Country	National Curriculum	Year Curriculum Introduced	Curriculum Under Revision	Curriculum Stucture Grade-to-Grade (Year-to-Year)	Examinations with Consequences for Individual Students	Grades with Examinations
Algeria	●	2004	●	7–8	●	11
Armenia	●	2006	●	5–8	●	8,10
Australia	○	–	●	varies by state	●	12
Austria	●	2000	○	5,6,7,8	●	12,13
Bahrain	○	2001	○	–	●	9,12
Bosnia and Herzegovina	○	2004	●	7–9	●	8,12
Botswana	●	1996	●	5–7,8–10	●	7,10,12
Bulgaria	●	1992	●	5–8	●	8,12–13
Chinese Taipei	●	2005	○	5–6,7–9	●	9
Colombia	○	2004	○	7–9	●	11
Cyprus	●	2003	●	7–9	●	7–12
Czech Republic	●	1996	●	6–9	○	–
Egypt	●	2003	○	7–9	○	–
El Salvador	●	1996	●	7–9	●	11–12
England	●	1999	●	6–8	●	5,8,10,12
Georgia	●	2005	●	7–9	○	–
Ghana	●	2007	○	7–9	●	9,12
Hong Kong SAR	●	2000	○	7–9	●	11,13
Hungary	●	2007	○	5–6,7–8	●	12
Indonesia	●	2004	●	7–9	○	–
Iran, Islamic Rep. of	●	2000	○	6–8	●	5,8,11,12
Israel	●	1996	○	7–9	●	12
Italy	●	2004	●	6–8	●	8,13
Japan	●	2002	●	7–9	●	9,12
Jordan	●	2005	○	1–10	●	12
Kazakhstan	●	2003	●	5–9	●	4–11
Korea, Rep. of	●	2001	●	7–9	●	12
Kuwait	●	1990	●	6,7,8,9	●	5–12
Lebanon	●	1997	●	7–9	○	–
Lithuania	●	2003	●	5–6,7–8	●	12
Malaysia	●	2003	○	7–9	●	6,9,11
Malta	●	2000	○	7–11	●	4–11
Mongolia	●	2004	○	–	●	9,11
Morocco	●	2001	○	7–9	●	6,9,11,12
Netherlands	●	2006	○	–	●	10,11, or 12
New Zealand	●	1995	●	6–8,8–10	●	10–12
Norway	●	2006	○	5–7,8–10	●	10,11–13
Oman	●	2004	○	5–10	●	12
Palestinian Nat'l Auth.	●	2003	●	5–10	●	4–12
Qatar	●	1990	●	5–6, 7–9	●	12
Romania	●	1998	●	5–8	●	12
Russian Federation	●	1998	●	5–9	●	9,11
Saudi Arabia	●	1999	●	7–9	●	–
Scotland	●	2000	●	7–8	●	10–12
Serbia	●	1990	●	K–8	○	–
Singapore	●	2001	●	7–8	●	6,10,12
Slovak Republic	●	1997	●	5–9	○	–
Slovenia	●	1999	●	7–9	●	12
Sweden	●	2000	○	6–9	○	–
Syrian Arab Republic	●	2002	●	7–9	●	9,12
Thailand	●	2001	●	7–9	●	6,9,12
Tunisia	●	1997	●	7,8,9	●	4,6,9,13
Turkey	●	2000	●	6–8	●	8
Ukraine	●	2001	●	5–11	●	9,11
United States	○	–	●	varies by state	○	–
Yemen	●	2001	○	7–9	●	9,12
Benchmarking Participants						
Alberta, Canada	○	1996	●	5,6,7,8,9	●	6,9,12
Basque Country, Spain	●	1992	●	7–9	●	12
British Columbia, Canada	○	2006	○	5,6,7,8	●	10,12
Dubai, UAE	●	2002	●	6–9	●	1–12
Massachusetts, US	○	2001	○	6–8	●	5,8,9–10
Minnesota, US	○	2004	○	6–8	○	–
Ontario, Canada	○	1998	●	5,6,7,8	○	–
Quebec, Canada	○	2005	○	7–8	●	10

● Yes ○ No

Data provided by National Research Coordinators.
A dash (–) indicates comparable data are not available.

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2007

Exhibit 7 Components Described by the Curriculum for Mathematics and Science

TIMSS2007 Mathematics & Science 4th Grade

Country	Goals and Objectives		Processes or Methods		Materials		Percentage of Students Reaching Defined Goals	
	Mathematics	Science	Mathematics	Science	Mathematics	Science	Mathematics	Science
Algeria	●	●	●	●	●	●	●	●
Armenia	●	●	●	●	●	●	●	●
Australia	●	●	●	●	●	●	○	○
Austria	●	●	●	●	○	○	○	○
Bosnia and Herzegovina	●	●	●	●	●	●	○	○
Botswana	●	●	●	●	●	●	○	○
Bulgaria	●	●	●	●	○	○	○	○
Chinese Taipei	●	●	○	●	●	●	●	○
Colombia	●	●	○	○	○	○	○	○
Cyprus	●	●	●	○	○	○	○	○
Czech Republic	●	●	○	○	○	○	○	○
Denmark	●	●	●	●	○	○	○	○
El Salvador	●	●	●	●	●	●	○	○
England	●	●	○	○	○	○	○	○
Georgia	●	●	●	○	●	○	○	○
Germany	●	●	●	●	○	●	○	○
Ghana	●	●	●	●	●	●	○	○
Hong Kong SAR	●	●	●	●	●	●	○	○
Hungary	●	●	○	○	●	●	○	○
Iran, Islamic Rep. of	●	●	●	●	●	●	○	○
Israel	●	●	○	●	○	○	○	○
Italy	●	●	●	●	○	○	○	○
Japan	●	●	●	●	●	●	○	○
Jordan	●	●	●	●	●	●	○	○
Kazakhstan	●	●	●	●	●	●	●	●
Korea, Rep. of	●	●	●	●	○	○	○	○
Kuwait	●	●	●	●	●	●	●	●
Latvia	●	●	○	○	○	○	○	○
Lithuania	●	●	●	●	●	●	○	○
Malaysia	●	●	●	●	●	●	○	○
Malta	●	●	○	●	●	●	○	○
Mongolia	●	●	●	●	●	●	○	○
Morocco	●	●	●	●	●	●	○	●
Netherlands	●	●	○	○	○	○	○	○
New Zealand	●	●	○	○	○	○	○	○
Norway	●	●	○	○	○	○	○	○
Oman	●	●	●	●	●	●	○	○
Palestinian Nat'l Auth.	●	●	●	●	●	●	○	○
Qatar	●	●	●	●	●	●	○	○
Romania	●	●	●	●	●	●	○	○
Russian Federation	●	●	○	○	○	○	○	○
Scotland	●	●	●	●	●	○	●	○
Serbia	●	●	●	○	○	●	○	○
Singapore	●	●	●	●	●	●	○	○
Slovak Republic	●	●	●	●	○	○	●	○
Slovenia	●	●	●	●	○	○	●	●
Sweden	●	●	○	○	○	○	●	●
Tunisia	●	●	●	●	●	●	○	○
Turkey	●	●	●	●	●	●	○	○
Ukraine	●	●	●	●	●	●	○	○
United States	●	●	●	●	○	○	○	○
Yemen	●	●	●	●	●	●	○	○
Benchmarking Participants								
Alberta, Canada	●	●	○	●	○	○	○	○
Basque Country, Spain	●	●	●	●	○	○	○	○
British Columbia, Canada	●	●	○	●	○	○	○	○
Dubai, UAE	●	●	●	●	●	●	○	○
Massachusetts, US	●	●	○	●	○	○	○	○
Minnesota, US	●	●	○	○	○	○	○	○
Ontario, Canada	●	●	●	●	●	○	○	○
Quebec, Canada	●	●	●	●	○	○	○	○

● Yes ○ No

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2007

Data provided by National Research Coordinators.

Exhibit 7 Components Described by the Curriculum for Mathematics and Science (Continued)

TIMSS2007 Mathematics & Science 8th Grade

Country	Goals and Objectives		Processes or Methods		Materials		Percentage of Students Reaching Defined Goals	
	Mathematics	Science	Mathematics	Science	Mathematics	Science	Mathematics	Science
Algeria	●	●	●	●	●	●	○	●
Armenia	●	●	●	●	●	●	●	●
Australia	●	●	●	●	○	○	○	○
Austria	●	●	●	●	○	○	○	○
Bahrain	●	○	●	●	●	●	○	○
Bosnia and Herzegovina	●	●	●	●	●	●	○	○
Botswana	●	●	●	●	●	●	○	○
Bulgaria	●	●	●	●	○	○	○	○
Chinese Taipei	●	●	●	●	●	●	○	○
Colombia	●	●	○	○	○	○	○	○
Cyprus	●	●	○	●	●	●	○	○
Czech Republic	●	●	○	○	○	○	○	○
Egypt	●	●	●	○	●	○	●	○
El Salvador	●	●	●	●	●	●	○	○
England	●	●	○	○	○	○	○	○
Georgia	●	●	●	○	●	○	○	○
Ghana	●	●	●	●	●	●	○	○
Hong Kong SAR	●	●	●	●	●	●	○	○
Hungary	●	●	○	○	●	●	○	○
Indonesia	●	●	●	●	●	●	○	○
Iran, Islamic Rep. of	●	●	●	●	●	●	○	○
Israel	●	●	●	●	●	○	○	○
Italy	●	●	●	●	○	○	○	○
Japan	●	●	●	●	●	●	○	○
Jordan	●	●	●	●	●	●	○	○
Kazakhstan	●	●	●	●	●	●	●	●
Korea, Rep. of	●	●	●	●	○	○	○	○
Kuwait	●	●	●	●	●	●	●	●
Lebanon	●	●	●	●	●	●	○	○
Lithuania	●	●	●	●	●	●	○	○
Malaysia	●	●	●	●	○	○	○	○
Malta	●	●	○	●	●	●	○	○
Mongolia	●	●	●	●	●	●	○	○
Morocco	●	●	●	●	●	●	○	○
Netherlands	●	●	○	○	○	○	○	○
New Zealand	●	●	○	○	○	○	○	○
Norway	●	●	○	○	○	○	○	○
Oman	●	●	●	●	●	●	○	○
Palestinian Nat'l Auth.	●	●	●	●	●	●	○	○
Qatar	●	●	●	●	●	●	○	○
Romania	●	●	●	●	●	●	○	○
Russian Federation	●	●	○	○	○	○	○	○
Saudi Arabia	●	●	●	●	●	●	○	○
Scotland	●	●	●	●	●	○	●	○
Serbia	●	●	●	○	○	●	○	○
Singapore	●	●	●	●	●	●	○	○
Slovak Republic	●	●	●	●	○	○	○	●
Slovenia	●	●	●	●	○	○	●	●
Sweden	●	●	○	○	○	○	●	●
Syrian Arab Republic	●	●	●	●	●	●	●	●
Thailand	●	●	●	●	●	●	○	○
Tunisia	●	●	●	○	●	●	○	○
Turkey	●	●	●	●	●	●	○	○
Ukraine	●	●	●	●	●	●	○	○
United States	●	●	●	●	○	○	○	○
Yemen	●	●	●	●	●	●	○	○
Benchmarking Participants								
Alberta, Canada	●	●	○	●	○	○	○	○
Basque Country, Spain	●	●	●	●	○	○	○	○
British Columbia, Canada	●	●	○	●	○	●	○	○
Dubai, UAE	●	●	●	●	●	●	○	○
Massachusetts, US	●	●	○	●	○	○	○	○
Minnesota, US	●	●	○	○	○	○	○	○
Ontario, Canada	●	●	●	●	●	○	○	○
Quebec, Canada	●	●	●	●	○	○	○	○

● Yes ○ No

Data provided by National Research Coordinators.

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2007

Approaches and Processes in the Intended Mathematics Curriculum

Exhibit 8 indicates the relative emphasis given to various aspects of mathematics instruction in the intended curriculum of participating countries, for both fourth and eighth grade. For each of the approaches and processes, participants were given four response options, including *a lot of emphasis, some emphasis, very little emphasis, and no emphasis.* In the intended mathematics curriculum at the fourth grade, as might be anticipated for students at this point in their education, the most emphasis was placed on mastering basic skills and procedures and understanding mathematical concepts and principles (46 and 36 countries, respectively). However, among benchmarking participants understanding mathematical concepts and principles, and applying mathematics in real-life contexts were given the most emphasis. Across all the countries, applying mathematics in real-life contexts was also given “a lot of emphasis” in the intended fourth grade curriculum in 20 countries. Communicating mathematically and reasoning mathematically were given at least “some emphasis” in almost half the countries’ curriculum. Integrating mathematics with other subjects was typically given “some” or “very little emphasis”. Incorporating the experiences of different ethnic/cultural groups was given the least emphasis in the fourth grade mathematics curriculum (46 countries and 6 benchmarking participants responded “no emphasis”, or “very little emphasis”).

At the eighth grade, “a lot of emphasis” was most commonly placed on mastering basic skills and procedures (46 countries and 7 benchmarking participants) and understanding mathematical concepts and principles (43 countries and all benchmarking participants). Applying mathematics in real-life contexts, communicating mathematically, reasoning mathematically, and integrating mathematics with other subjects were given “some emphasis” in more than half the countries. Deriving formal proofs was typically given “some emphasis” or “very little emphasis”. As in the fourth grade, incorporating the experiences of different ethnic/cultural groups was given the least emphasis across countries and benchmarking participants.

Approaches and Processes in the Intended Science Curriculum

In Exhibit 9, data are provided from countries on the relative emphasis given to various aspects of science instruction in the intended curriculum for both fourth and eighth grades based on the same response options as were provided for mathematics. In the intended science curriculum at both grades, the most emphasis was placed on knowing basic science facts and principles (38 countries and 6 benchmarking participants at the fourth grade and 45 and 6, respectively for the eighth grade). The following approaches were typically given “a lot of emphasis” or “some emphasis” at both grades: observing natural phenomena and describing what is seen, providing explanations about what is being studied, and conducting experiments or investigations. Designing and planning experiments or investigations, integrating science with other subjects, and relating what students are learning to their daily lives were given at least some emphasis in the fourth and eighth grade curricula. For both the countries and benchmarking participants, and at both grades, incorporating the experiences of different ethnic/cultural groups was given the least emphasis (45 countries and 5 benchmarking participants at the fourth grade and 47 and 4, respectively at the eighth grade responded "no emphasis" or "very little emphasis").

How the Curriculum Addresses Students with Different Levels of Ability

The challenge of maximizing opportunity to learn for students with widely varying abilities is met differently in different countries. Exhibit 10 indicates how countries addressed this issue in organizing the intended mathematics and science curricula, first for countries that participated at the fourth grade and then for those at the eighth grade.

At both grades and in both subjects, the majority of participants reported having just one curriculum for all students, with no grouping of students. Of the countries that did not report having one curriculum for all fourth grade students, seven reported having different difficulty levels for groups of students with different ability levels under one curriculum. Only one country, Kazakhstan, reported having different curricula for different groups of students according to their ability levels.

At the eighth grade, 13 countries reported having one curriculum for all students but different difficulty levels for those students with different ability levels. Only 4 countries at the eighth grade—Kazakhstan, Malta, Singapore, and the Ukraine—reported having different curricula for groups of students according to ability level.

Another indicator of how countries address students of different ability levels is whether or not they have a policy to provide remedial instruction in mathematics or science. At the fourth grade, 23 countries and 3 benchmarking participants reported having a policy to provide remedial instruction in mathematics, and 16 and 2, respectively, in science. Similarly, at the eighth grade, 26 countries and 3 benchmarking participants have the same policy in mathematics, and 16 and 2, respectively, in science. At both grades, there were more participants reporting having this policy in mathematics than in science.

Exhibit 8 Emphasis on Approaches and Processes in the Intended Mathematics Curriculum

TIMSS2007 Mathematics 4th Grade

Country	Mastering Basic Skills and Procedures	Understanding Mathematical Concepts and Principles	Applying Mathematics in Real-life Contexts	Communicating Mathematically	Reasoning Mathematically	Incorporating the Experiences of Different Ethnic/ Cultural Groups	Integrating Mathematics with Other Subjects
Algeria	●	◉	●	-	⊙	⊙	●
Armenia	●	●	◉	◉	◉	⊙	●
Australia	●	●	●	●	●	◉	◉
Austria	●	●	●	◉	◉	◉	◉
Bosnia and Herzegovina	●	⊙	◉	⊙	◉	⊙	◉
Botswana	●	●	◉	◉	◉	◉	◉
Bulgaria	●	●	⊙	◉	◉	○	◉
Chinese Taipei	◉	●	●	◉	◉	○	◉
Colombia	●	●	◉	◉	◉	○	⊙
Cyprus	●	●	◉	●	●	⊙	◉
Czech Republic	●	●	◉	⊙	⊙	○	○
Denmark	●	●	●	●	●	○	○
El Salvador	●	●	◉	⊙	◉	○	⊙
England	●	●	◉	◉	◉	⊙	⊙
Georgia	●	◉	⊙	●	◉	⊙	⊙
Germany	●	●	◉	◉	◉	⊙	◉
Ghana	●	◉	⊙	○	○	○	◉
Hong Kong SAR	●	●	●	●	●	●	◉
Hungary	●	⊙	◉	⊙	◉	○	⊙
Iran, Islamic Rep. of	●	●	◉	◉	●	⊙	⊙
Israel	●	●	◉	◉	◉	○	⊙
Italy	●	●	●	◉	●	○	◉
Japan	●	●	◉	◉	●	○	○
Jordan	●	◉	◉	◉	◉	⊙	◉
Kazakhstan	●	●	◉	●	⊙	⊙	◉
Korea, Rep. of	●	●	●	⊙	◉	○	⊙
Kuwait	●	●	◉	◉	●	○	●
Latvia	●	◉	◉	◉	⊙	○	⊙
Lithuania	●	◉	●	●	◉	○	⊙
Malaysia	●	●	●	●	●	◉	●
Malta	●	●	●	◉	●	○	●
Mongolia	◉	◉	◉	◉	◉	⊙	◉
Morocco	●	●	●	○	○	○	○
Netherlands	◉	⊙	◉	○	●	○	○
New Zealand	◉	◉	◉	◉	◉	⊙	⊙
Norway	●	◉	●	◉	⊙	○	⊙
Palestinian Nat'l Auth.	●	◉	●	⊙	⊙	○	⊙
Oman	●	●	●	●	●	○	●
Qatar	●	●	◉	⊙	⊙	○	⊙
Romania	●	●	◉	●	●	○	⊙
Russian Federation	●	●	⊙	⊙	⊙	○	⊙
Scotland	●	●	◉	◉	◉	⊙	◉
Serbia	●	●	◉	⊙	◉	⊙	◉
Singapore	●	●	●	●	●	◉	◉
Slovak Republic	●	◉	⊙	○	⊙	○	⊙
Slovenia	◉	◉	◉	◉	⊙	○	⊙
Sweden	●	●	●	●	●	⊙	◉
Tunisia	●	●	●	●	●	○	○
Turkey	●	●	⊙	⊙	◉	○	⊙
Ukraine	◉	⊙	●	⊙	⊙	○	◉
United States	●	●	●	●	◉	⊙	◉
Yemen	●	●	◉	◉	⊙	○	⊙
Benchmarking Participants							
Alberta, Canada	◉	●	◉	●	●	◉	◉
Basque Country, Spain	●	●	●	◉	◉	○	⊙
British Columbia, Canada	●	●	●	●	●	◉	◉
Dubai, UAE	●	●	●	◉	◉	○	◉
Massachusetts, US	●	●	●	●	●	○	⊙
Minnesota, US	●	●	●	◉	●	○	○
Ontario, Canada	●	●	●	●	●	⊙	◉
Quebec, Canada	◉	●	●	●	●	⊙	◉

● A Lot of Emphasis ◉ Some Emphasis ⊙ Very Little Emphasis ○ No Emphasis

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2007

Data provided by National Research Coordinators.
A dash (–) indicates comparable data are not available.

Exhibit 8 Emphasis on Approaches and Processes in the Intended Mathematics Curriculum (Continued)

TIMSS2007 Mathematics 8th Grade

Country	Mastering Basic Skills and Procedures	Understanding Mathematical Concepts and Principles	Applying Mathematics in Real-life Contexts	Communicating Mathematically	Reasoning Mathematically	Incorporating the Experiences of Different Ethnic/Cultural Groups	Integrating Mathematics with Other Subjects	Deriving Formal Proofs
Algeria	●	●	●	◉	●	○	◉	◉
Armenia	●	●	◉	◉	●	⊙	●	●
Australia	●	●	●	●	●	◉	◉	○
Austria	●	●	◉	◉	◉	○	◉	●
Bahrain	●	●	⊙	⊙	○	○	◉	◉
Bosnia and Herzegovina	●	◉	⊙	⊙	◉	⊙	⊙	○
Botswana	●	●	●	◉	◉	◉	◉	◉
Bulgaria	●	●	⊙	◉	◉	○	◉	●
Chinese Taipei	●	●	◉	◉	◉	○	⊙	⊙
Colombia	●	●	◉	◉	◉	○	◉	◉
Cyprus	●	◉	⊙	◉	⊙	⊙	⊙	⊙
Czech Republic	●	●	●	◉	◉	○	⊙	⊙
Egypt	⊙	◉	⊙	⊙	◉	○	⊙	◉
El Salvador	●	●	◉	◉	●	○	◉	○
England	●	●	◉	◉	◉	⊙	⊙	◉
Georgia	◉	●	●	●	●	◉	◉	◉
Ghana	●	●	◉	⊙	⊙	○	◉	⊙
Hong Kong SAR	◉	◉	◉	◉	◉	⊙	⊙	◉
Hungary	●	●	◉	◉	●	○	◉	◉
Indonesia	●	●	◉	⊙	⊙	○	⊙	⊙
Iran, Islamic Rep. of	●	●	◉	◉	◉	⊙	◉	◉
Israel	◉	◉	◉	◉	◉	○	⊙	●
Italy	●	●	●	●	●	○	◉	○
Japan	●	●	◉	◉	●	○	○	●
Jordan	●	◉	◉	◉	◉	⊙	◉	◉
Kazakhstan	●	●	◉	●	⊙	⊙	◉	-
Korea, Rep. of	●	●	●	⊙	◉	○	⊙	●
Kuwait	●	●	◉	◉	◉	○	●	●
Lebanon	◉	●	◉	◉	●	○	◉	●
Lithuania	●	◉	⊙	◉	◉	○	⊙	⊙
Malaysia	●	●	●	●	●	⊙	◉	⊙
Malta	●	●	◉	●	●	⊙	◉	⊙
Mongolia	◉	◉	◉	◉	◉	⊙	◉	◉
Morocco	●	●	⊙	○	◉	○	○	○
Netherlands	◉	◉	◉	●	●	○	○	○
New Zealand	◉	◉	◉	◉	◉	◉	⊙	⊙
Norway	●	◉	●	◉	◉	○	⊙	○
Oman	●	●	●	◉	●	◉	●	◉
Palestinian Nat'l Auth.	●	●	⊙	⊙	◉	○	◉	◉
Qatar	●	●	◉	⊙	◉	○	◉	●
Romania	●	●	◉	●	●	○	⊙	⊙
Russian Federation	●	●	⊙	⊙	◉	○	⊙	◉
Saudi Arabia	●	●	◉	◉	●	-	◉	●
Scotland	●	●	◉	◉	●	⊙	◉	⊙
Serbia	●	●	⊙	◉	●	⊙	◉	◉
Singapore	●	●	●	●	●	◉	◉	⊙
Slovak Republic	●	◉	⊙	○	⊙	○	⊙	⊙
Slovenia	●	●	◉	◉	◉	⊙	⊙	⊙
Sweden	●	●	●	●	●	⊙	◉	○
Syrian Arab Republic	◉	●	⊙	○	⊙	●	⊙	●
Thailand	●	●	◉	◉	●	●	⊙	●
Tunisia	●	●	◉	◉	◉	○	○	○
Turkey	●	●	⊙	⊙	◉	○	⊙	⊙
Ukraine	◉	◉	⊙	⊙	◉	○	◉	◉
United States	●	●	●	●	◉	⊙	⊙	⊙
Yemen	●	●	◉	◉	⊙	○	⊙	◉
Benchmarking Participants								
Alberta, Canada	●	●	●	●	●	◉	◉	◉
Basque Country, Spain	●	●	●	◉	◉	○	⊙	-
British Columbia, Canada	●	●	●	●	●	◉	◉	⊙
Dubai, UAE	●	●	●	◉	◉	○	◉	●
Massachusetts, US	●	●	●	●	●	○	⊙	◉
Minnesota, US	●	●	●	◉	●	○	○	○
Ontario, Canada	●	●	●	●	●	◉	●	●
Quebec, Canada	◉	●	●	●	●	⊙	◉	◉

● A Lot of Emphasis ◉ Some Emphasis ⊙ Very Little Emphasis ○ No Emphasis

Data provided by National Research Coordinators.

A dash (–) indicates comparable data are not available.

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2007

Exhibit 9 Emphasis on Approaches and Processes in the Intended Science Curriculum

TIMSS2007 Science 4th Grade

Country	Knowing Basic Science Facts and Principles	Observing Natural Phenomena and Describing What Is Seen	Providing Explanations About What Is Being Studied	Designing and Planning Experiments or Investigations	Conducting Experiments or Investigations	Integrating Science with Other Subjects	Relating What Students Are Learning to Their Daily Lives	Incorporating the Experiences of Different Ethnic/Cultural Groups
Algeria	●	●	●	●	●	●	●	⊙
Armenia	●	●	●	◉	◉	◉	◉	⊙
Australia	◉	●	●	●	●	●	●	◉
Austria	●	●	●	◉	◉	●	●	◉
Bosnia and Herzegovina	●	◉	⊙	⊙	⊙	◉	◉	⊙
Botswana	●	●	⊙	⊙	⊙	◉	●	○
Bulgaria	●	◉	◉	◉	⊙	◉	⊙	○
Chinese Taipei	●	●	●	⊙	●	●	◉	⊙
Colombia	●	◉	◉	◉	◉	⊙	◉	⊙
Cyprus	◉	◉	⊙	⊙	⊙	⊙	◉	○
Czech Republic	●	◉	◉	○	○	⊙	◉	○
Denmark	●	●	●	●	●	◉	●	●
El Salvador	◉	◉	◉	⊙	⊙	◉	◉	○
England	●	●	◉	◉	●	⊙	◉	⊙
Georgia	●	◉	⊙	⊙	⊙	◉	⊙	○
Germany	●	●	◉	●	●	●	●	⊙
Ghana	●	●	◉	⊙	⊙	◉	◉	◉
Hong Kong SAR	◉	◉	◉	⊙	⊙	●	◉	⊙
Hungary	⊙	◉	⊙	○	⊙	⊙	●	○
Iran, Islamic Rep. of	◉	●	⊙	◉	◉	◉	◉	○
Israel	●	●	●	●	●	●	●	◉
Italy	●	●	●	●	●	◉	◉	○
Japan	●	●	●	●	●	◉	◉	○
Jordan	●	●	●	⊙	●	◉	●	○
Kazakhstan	●	◉	●	⊙	⊙	●	◉	⊙
Korea, Rep. of	●	●	◉	⊙	●	⊙	◉	○
Kuwait	●	◉	●	●	●	◉	◉	○
Latvia	◉	◉	◉	◉	◉	⊙	◉	○
Lithuania	◉	◉	⊙	⊙	⊙	◉	◉	⊙
Malaysia	●	●	⊙	◉	◉	○	●	○
Malta	◉	●	⊙	◉	●	⊙	◉	○
Mongolia	◉	⊙	◉	◉	⊙	◉	◉	⊙
Morocco	●	◉	◉	●	●	●	●	○
Netherlands	●	●	◉	◉	◉	⊙	⊙	○
New Zealand	⊙	⊙	◉	⊙	◉	◉	◉	⊙
Norway	●	◉	◉	◉	◉	⊙	●	⊙
Oman	◉	●	●	◉	●	⊙	●	⊙
Palestinian Nat'l Auth.	●	◉	◉	⊙	◉	◉	◉	○
Qatar	●	●	●	◉	◉	●	◉	○
Romania	◉	●	●	◉	●	◉	●	○
Russian Federation	●	◉	◉	⊙	◉	⊙	⊙	○
Scotland	●	◉	●	◉	◉	◉	⊙	⊙
Serbia	●	◉	◉	○	⊙	⊙	◉	⊙
Singapore	●	●	●	◉	●	◉	●	◉
Slovak Republic	●	⊙	⊙	○	◉	⊙	⊙	○
Slovenia	●	◉	◉	◉	⊙	●	⊙	○
Sweden	●	◉	●	●	●	◉	●	◉
Tunisia	●	◉	●	●	●	◉	◉	○
Turkey	●	●	●	●	●	◉	●	○
Ukraine	◉	◉	◉	⊙	⊙	◉	◉	○
United States	●	●	●	◉	⊙	⊙	◉	⊙
Yemen	●	◉	◉	⊙	◉	◉	◉	○
Benchmarking Participants								
Alberta, Canada	●	●	◉	●	●	◉	●	◉
Basque Country, Spain	●	●	●	◉	◉	⊙	◉	○
British Columbia, Canada	●	●	●	◉	●	◉	◉	◉
Dubai, UAE	●	●	●	●	●	●	◉	○
Massachusetts, US	●	●	●	◉	⊙	⊙	⊙	⊙
Minnesota, US	◉	●	●	●	●	⊙	◉	⊙
Ontario, Canada	●	●	●	●	●	◉	●	◉
Quebec, Canada	◉	●	●	◉	◉	●	●	⊙

● A Lot of Emphasis ◉ Some Emphasis ⊙ Very Little Emphasis ○ No Emphasis

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2007

Data provided by National Research Coordinators.

Exhibit 9 Emphasis on Approaches and Processes in the Intended Science Curriculum (Continued)

TIMSS2007 Science 8th Grade

Country	Knowing Basic Science Facts and Principles	Observing Natural Phenomena and Describing What Is Seen	Providing Explanations About What Is Being Studied	Designing and Planning Experiments or Investigations	Conducting Experiments or Investigations	Integrating Science with Other Subjects	Relating What Students Are Learning to Their Daily Lives	Incorporating the Experiences of Different Ethnic/Cultural Groups
Algeria	●	●	◉	◉	◉	⊙	◉	○
Armenia	●	●	●	◉	◉	◉	◉	⊙
Australia	◉	●	●	●	●	◉	●	◉
Austria	●	●	◉	⊙	◉	◉	◉	○
Bahrain	●	◉	◉	⊙	⊙	⊙	⊙	○
Bosnia and Herzegovina	●	◉	⊙	⊙	⊙	⊙	⊙	⊙
Botswana	●	●	●	●	●	◉	●	⊙
Bulgaria	●	◉	◉	◉	⊙	◉	⊙	○
Chinese Taipei	●	◉	●	⊙	⊙	◉	◉	⊙
Colombia	●	◉	◉	◉	◉	⊙	◉	⊙
Cyprus	●	●	●	⊙	●	○	⊙	–
Czech Republic	●	◉	◉	○	○	⊙	⊙	○
Egypt	●	⊙	◉	⊙	⊙	⊙	◉	○
El Salvador	●	◉	◉	◉	◉	◉	◉	○
England	●	●	●	◉	●	⊙	◉	◉
Georgia	◉	●	●	●	●	◉	●	◉
Ghana	●	◉	●	◉	◉	◉	◉	⊙
Hong Kong SAR	●	◉	◉	●	●	◉	●	⊙
Hungary	●	◉	⊙	⊙	◉	⊙	◉	○
Indonesia	●	◉	◉	◉	◉	⊙	⊙	○
Iran, Islamic Rep. of	◉	●	◉	◉	◉	⊙	◉	○
Israel	●	◉	●	◉	●	●	●	⊙
Italy	●	●	●	●	●	◉	◉	○
Japan	●	●	●	●	●	◉	◉	○
Jordan	●	●	●	◉	◉	●	●	○
Korea, Rep. of	●	●	◉	⊙	●	⊙	◉	○
Kuwait	●	●	◉	●	●	●	●	○
Lebanon	◉	◉	◉	●	◉	⊙	◉	○
Lithuania	◉	◉	◉	◉	◉	◉	◉	○
Malaysia	●	●	●	◉	●	◉	●	⊙
Malta	●	◉	●	⊙	⊙	◉	●	◉
Mongolia	◉	◉	◉	◉	◉	⊙	◉	◉
Morocco	●	●	●	●	●	◉	◉	○
Netherlands	◉	●	◉	●	●	●	●	○
New Zealand	⊙	⊙	◉	⊙	◉	◉	◉	⊙
Norway	●	◉	◉	◉	◉	⊙	●	⊙
Oman	◉	●	●	◉	●	⊙	●	⊙
Palestinian Nat'l Auth.	●	◉	◉	⊙	◉	◉	◉	○
Qatar	●	●	●	◉	◉	◉	◉	○
Romania	●	◉	◉	⊙	⊙	⊙	⊙	○
Russian Federation	●	◉	◉	⊙	◉	⊙	⊙	○
Saudi Arabia	●	●	●	◉	◉	◉	⊙	○
Scotland	●	◉	●	◉	◉	◉	⊙	⊙
Serbia	●	⊙	◉	○	⊙	⊙	◉	○
Singapore	●	●	●	◉	●	◉	●	◉
Slovak Republic	●	⊙	⊙	○	⊙	⊙	⊙	○
Slovenia	●	◉	◉	◉	⊙	●	⊙	○
Sweden	●	◉	●	●	●	◉	●	◉
Syrian Arab Republic	●	●	●	◉	◉	◉	◉	⊙
Thailand	●	●	●	●	●	⊙	◉	⊙
Tunisia	●	◉	⊙	⊙	⊙	○	⊙	○
Turkey	●	●	●	●	●	●	●	○
Ukraine	◉	◉	◉	⊙	⊙	◉	◉	○
United States	●	●	●	●	●	⊙	◉	⊙
Yemen	●	●	◉	◉	◉	◉	●	○
Benchmarking Participants								
Alberta, Canada	●	●	●	●	●	◉	●	◉
Basque Country, Spain	●	●	●	◉	◉	⊙	◉	○
British Columbia, Canada	●	●	●	◉	●	◉	◉	◉
Dubai, UAE	●	●	●	●	●	◉	●	●
Massachusetts, US	●	●	●	◉	⊙	⊙	⊙	⊙
Minnesota, US	◉	●	●	●	●	⊙	◉	⊙
Ontario, Canada	●	●	●	●	●	◉	●	◉
Quebec, Canada	◉	●	●	●	●	●	●	⊙

● A Lot of Emphasis ◉ Some Emphasis ⊙ Very Little Emphasis ○ No Emphasis

Data provided by National Research Coordinators.

A dash (–) indicates comparable data are not available.

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2007

Exhibit 10 The Way the Intended Curriculum for Mathematics and Science Addresses the Issue of Students with Different Levels of Ability

TIMSS2007 Mathematics & Science 4th Grade

Country	One Curriculum for All Students with No Grouping		One Curriculum for All Students, but Different Groups of Students Have Different Difficulty Levels		Different Curricula for Different Groups of Students According to Ability Level		Policy to Provide Remedial Instruction	
	Mathematics	Science	Mathematics	Science	Mathematics	Science	Mathematics	Science
Algeria	●	●	○	○	○	○	●	●
Armenia	●	●	○	○	○	○	●	○
Australia	●	●	○	○	○	○	○	○
Austria	●	●	○	○	○	○	●	○
Bosnia and Herzegovina	●	●	○	○	○	○	●	●
Botswana	●	●	○	○	○	○	○	○
Bulgaria	●	●	○	○	○	○	○	○
Chinese Taipei	●	●	○	○	○	○	●	○
Colombia	●	●	○	○	○	○	●	●
Cyprus	●	●	○	○	○	○	○	○
Czech Republic	●	●	○	○	○	○	○	○
Denmark	●	●	○	○	○	○	○	○
El Salvador	●	●	○	○	○	○	○	○
England	●	●	○	○	○	○	○	○
Georgia	●	●	○	○	○	○	●	●
Germany	●	●	○	○	○	○	●	○
Ghana	●	●	○	○	○	○	○	○
Hong Kong SAR	○	●	●	○	○	○	○	○
Hungary	●	●	○	○	○	○	○	○
Iran, Islamic Rep. of	●	●	○	○	○	○	○	○
Israel	●	●	○	○	○	○	○	○
Italy	●	●	○	○	○	○	●	●
Japan	●	●	○	○	○	○	●	●
Jordan	●	●	○	○	○	○	●	●
Kazakhstan	○	○	○	○	●	●	●	●
Korea, Rep. of	○	○	●	●	○	○	●	○
Kuwait	○	○	●	●	○	○	○	-
Latvia	●	●	○	○	○	○	○	○
Lithuania	●	●	○	○	○	○	●	●
Malaysia	●	●	○	○	○	○	●	○
Malta	●	●	○	○	○	○	○	○
Mongolia	●	●	○	○	○	○	○	○
Morocco	●	●	○	○	○	○	●	●
Netherlands	●	●	○	○	○	○	○	○
New Zealand	●	●	○	○	○	○	○	○
Norway	●	●	○	○	○	○	●	●
Oman	○	●	●	○	○	○	○	○
Palestinian Nat'l Auth.	●	●	○	○	○	○	●	●
Qatar	●	●	○	○	○	○	○	○
Romania	●	●	○	○	○	○	○	○
Russian Federation	●	●	○	○	○	○	○	○
Scotland	○	○	●	●	○	○	○	○
Serbia	●	●	○	○	○	○	●	○
Singapore	●	●	○	○	○	○	○	○
Slovak Republic	●	●	○	○	○	○	○	○
Slovenia	○	○	●	●	○	○	●	●
Sweden	●	●	○	○	○	○	●	●
Tunisia	●	●	○	○	○	○	●	●
Turkey	●	●	○	○	○	○	○	○
Ukraine	●	●	○	○	○	○	●	●
United States	○	○	●	●	○	○	○	○
Yemen	●	●	○	○	○	○	○	○
Benchmarking Participants								
Alberta, Canada	●	●	○	○	○	○	○	○
Basque Country, Spain	●	●	○	○	○	○	●	●
British Columbia, Canada	●	●	○	○	○	○	○	○
Dubai, UAE	●	●	○	○	○	○	●	●
Massachusetts, US	●	●	○	○	○	○	●	○
Minnesota, US	●	●	○	○	○	○	○	○
Ontario, Canada	●	●	○	○	○	○	○	○
Quebec, Canada	●	●	○	○	○	○	○	○

● Yes ○ No

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2007

Data provided by National Research Coordinators.
A dash (–) indicates comparable data are not available.

TIMSS & PIRLS International Study Center
Lynch School of Education, Boston College

Exhibit 10 The Way the Intended Curriculum for Mathematics and Science Addresses the Issue of Students with Different Levels of Ability (Continued)

TIMSS2007 Mathematics & Science 8th Grade

Country	One Curriculum for All Students with No Grouping		One Curriculum for All Students, but Different Groups of Students Have Different Difficulty Levels		Different Curricula for Different Groups of Students According to Ability Level		Policy to Provide Remedial Instruction	
	Mathematics	Science	Mathematics	Science	Mathematics	Science	Mathematics	Science
Algeria	○	●	●	○	○	○	●	○
Armenia	●	●	○	○	○	○	○	○
Australia	●	●	○	○	○	○	○	○
Austria	●	●	○	○	○	○	●	●
Bahrain	●	●	○	○	○	○	●	○
Bosnia and Herzegovina	●	●	○	○	○	○	●	●
Botswana	●	●	○	○	○	○	○	○
Bulgaria	●	●	○	○	○	○	○	○
Chinese Taipei	●	●	○	○	○	○	●	○
Colombia	●	●	○	○	○	○	●	●
Cyprus	●	●	○	○	○	○	●	○
Czech Republic	●	●	○	○	○	○	○	○
Egypt	●	●	○	○	○	○	○	○
El Salvador	●	●	○	○	○	○	○	○
England	●	●	○	○	○	○	○	○
Georgia	○	○	●	●	○	○	●	●
Ghana	●	●	○	○	○	○	○	○
Hong Kong SAR	○	○	●	●	○	○	●	○
Hungary	●	●	○	○	○	○	○	○
Indonesia	●	●	○	○	○	○	●	○
Iran, Islamic Rep. of	●	●	○	○	○	○	○	○
Israel	○	●	●	○	○	○	○	○
Italy	●	●	○	○	○	○	●	●
Japan	●	●	○	○	○	○	●	●
Jordan	●	●	○	○	○	○	●	●
Kazakhstan	○	○	○	○	●	●	●	●
Korea, Rep. of	○	○	●	●	○	○	●	○
Kuwait	○	○	●	●	○	○	○	●
Lebanon	●	●	○	○	○	○	●	○
Lithuania	●	●	○	○	○	○	●	●
Malaysia	●	●	○	○	○	○	○	○
Malta	○	○	○	●	●	○	●	○
Mongolia	●	●	○	○	○	○	○	○
Morocco	●	●	○	○	○	○	○	●
Netherlands	●	●	○	○	○	○	○	○
New Zealand	●	●	○	○	○	○	○	○
Norway	●	●	○	○	○	○	●	●
Oman	○	●	●	○	○	○	○	○
Palestinian Nat'l Auth.	●	●	○	○	○	○	○	○
Qatar	○	●	●	○	○	○	○	○
Romania	●	●	○	○	○	○	○	○
Russian Federation	●	●	○	○	○	○	○	○
Saudi Arabia	●	●	○	○	○	○	●	●
Scotland	○	○	●	●	○	○	○	○
Serbia	●	●	○	○	○	○	●	○
Singapore	○	○	○	○	●	●	○	○
Slovak Republic	●	●	○	○	○	○	○	○
Slovenia	○	○	●	●	○	○	●	●
Sweden	●	●	○	○	○	○	●	●
Syrian Arab Republic	○	●	●	○	○	○	●	○
Thailand	●	●	○	○	○	○	○	○
Tunisia	●	●	○	○	○	○	●	●
Turkey	●	●	○	○	○	○	○	○
Ukraine	○	○	○	○	●	●	●	○
United States	○	○	●	●	○	○	○	○
Yemen	●	●	○	○	○	○	○	○
Benchmarking Participants								
Alberta, Canada	●	●	○	○	○	○	○	○
Basque Country, Spain	●	●	○	○	○	○	●	●
British Columbia, Canada	●	●	○	○	○	○	○	○
Dubai, UAE	●	●	○	○	○	○	●	●
Massachusetts, US	●	●	○	○	○	○	●	○
Minnesota, US	●	●	○	○	○	○	○	○
Ontario, Canada	●	●	○	○	○	○	○	○
Quebec, Canada	●	●	○	○	○	○	○	○

Data provided by National Research Coordinators.

● Yes ○ No

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2007

Format in Which the Curriculum Is Made Available

In order to ensure that the goals and objectives of the intended curriculum reach the classroom, education systems make the curriculum available in a variety of formats. Official publications containing the curriculum, ministry notes and directives, textbooks, and instructional guides and activities are used to ensure that the curriculum is available and clear. The different formats used by the TIMSS 2007 countries to make the curriculum for mathematics and science available are shown in Exhibit 11.

At both the fourth and eighth grades, the most widely used formats were an official publication containing the curriculum and ministry notes and directives. The use of mandated or recommended textbooks and the instructional or pedagogical guide formats as a means of supporting mathematics and science curricula also were generally employed. The least widely used format was specifically developed or recommended instructional activities in mathematics and science.

Methods Used to Evaluate the Implementation of the Curriculum

Education systems use different ways to achieve the best match between the intended and the implemented curriculum for mathematics and science. The use of national or regional assessments as a mechanism to support and monitor implementation of the intended curriculum is prevalent among many countries. Other ways to help ensure alignment include evaluating the implementation of the curriculum through visits by inspectors, research programs, and school self-evaluation. Of the ways to evaluate the implementation of the mathematics curriculum, the four methods reported in Exhibit 12 were widely used with the exception of research programs, which were less widely used at the fourth grade (34 countries). Also, national or regional assessments were somewhat less frequently used in science.

Teacher Education and Certification

Exhibits 13 and 14 present information about the preparation of primary/elementary grade and middle/lower secondary grade teachers, including information about the licensing and/or certification requirements for teaching mathematics and science at these levels. Despite some differences, the general preparation and certification requirements were similar.

A degree from a teacher education program and a prepracticum during a teacher education program were the most commonly reported requirements at both grades and across both subjects. Completing a supervised practicum in the field, passing a certification examination, and completing a probationary teaching period were the next most commonly reported requirements. More than half of the countries reported having these requirements. In both subjects, the least common requirement was completion of a mentoring or induction program. At the primary/elementary level, only 10 countries in mathematics and 12 in science reported this requirement. At the middle/lower secondary level, 15 countries, in both subjects, reported requiring this for certification.

Among benchmarking participants, across both grades and subjects, a degree from a teacher education program and requiring some type of practicum—prepracticum during teacher education program or supervised practicum in the field—were the most commonly reported practices. Completion of a mentoring or induction program was the least commonly reported requirement.

Exhibit 11 Format in Which the Curriculum for Mathematics and Science Is Made Available

TIMSS2007 Mathematics & Science 4th Grade

Country	Official Publication Containing the Curriculum		Ministry Notes and Directives		Mandated or Recommended Textbooks		Instructional or Pedagogical Guide		Specifically Developed or Recommended Instructional Activities	
	Mathematics	Science	Mathematics	Science	Mathematics	Science	Mathematics	Science	Mathematics	Science
Algeria	●	●	●	○	●	●	●	●	●	○
Armenia	●	●	●	●	●	●	●	●	●	●
Australia	●	●	●	●	○	○	●	●	●	●
Austria	●	●	●	●	●	●	●	●	●	●
Bosnia and Herzegovina	●	●	●	●	○	○	○	○	●	●
Botswana	●	●	●	●	●	●	●	●	●	●
Bulgaria	●	●	●	●	○	○	●	●	●	●
Chinese Taipei	●	●	●	●	●	●	●	●	●	●
Colombia	●	●	●	●	○	○	○	○	○	○
Cyprus	●	●	●	○	●	●	●	○	●	○
Czech Republic	●	●	●	●	○	○	○	●	○	●
Denmark	●	●	●	●	○	○	●	●	○	○
El Salvador	●	●	●	○	●	●	○	○	●	●
England	●	●	○	○	○	○	○	○	●	●
Georgia	●	●	●	●	●	●	○	○	○	○
Germany	●	●	●	●	●	●	○	○	○	○
Ghana	●	●	○	○	●	●	●	●	●	●
Hong Kong SAR	●	●	●	●	●	●	●	●	●	●
Hungary	●	●	○	○	○	○	○	○	○	○
Iran, Islamic Rep. of	○	●	●	●	●	●	●	●	○	○
Israel	●	●	●	●	●	●	○	●	○	●
Italy	●	●	●	●	○	○	●	●	○	○
Japan	●	●	●	●	●	●	●	●	●	●
Jordan	●	●	●	●	●	●	●	●	●	●
Kazakhstan	●	●	●	●	●	●	●	●	●	●
Korea, Rep. of	●	●	●	●	●	●	●	●	●	○
Kuwait	●	●	●	●	●	●	●	●	●	●
Latvia	●	●	●	●	●	●	●	●	○	○
Lithuania	●	●	●	●	●	●	●	○	○	○
Malaysia	●	●	●	●	○	●	●	●	●	●
Malta	●	●	●	●	●	●	●	●	○	○
Mongolia	○	○	●	●	●	●	●	●	○	●
Morocco	●	○	●	○	○	●	●	○	○	○
Netherlands	●	●	●	●	○	○	●	○	●	○
New Zealand	●	●	●	●	○	○	●	●	●	●
Norway	●	●	●	●	○	○	○	○	○	○
Oman	●	●	●	●	●	●	○	○	○	○
Palestinian Nat'l Auth.	●	●	○	○	○	○	●	●	●	●
Qatar	○	○	●	●	●	●	●	●	●	●
Romania	●	●	●	●	●	●	○	●	○	●
Russian Federation	●	●	●	●	●	●	●	○	●	○
Scotland	●	●	○	○	○	○	○	●	○	●
Serbia	●	●	●	●	●	●	●	○	●	○
Singapore	●	●	●	●	●	●	●	●	●	●
Slovak Republic	●	●	●	●	●	●	●	●	○	○
Slovenia	●	●	●	●	●	●	○	○	○	○
Sweden	●	●	●	●	○	○	○	○	○	○
Tunisia	●	●	○	○	●	●	●	●	●	●
Turkey	●	●	●	●	●	●	●	●	●	●
Ukraine	●	●	●	●	●	●	●	●	●	●
United States	●	●	●	●	●	●	●	●	●	●
Yemen	●	●	●	●	●	●	●	●	○	○
Benchmarking Participants										
Alberta, Canada	●	●	○	○	●	●	○	○	●	●
Basque Country, Spain	●	●	○	●	○	○	●	●	○	○
British Columbia, Canada	●	●	○	○	●	●	●	●	○	○
Dubai, UAE	●	●	●	●	○	●	●	●	○	●
Massachusetts, US	●	●	●	○	○	○	○	○	○	○
Minnesota, US	●	●	●	●	○	○	○	○	○	○
Ontario, Canada	●	●	●	●	●	●	●	○	●	○
Quebec, Canada	●	●	●	●	○	●	○	○	○	○

● Yes ○ No

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2007

Data provided by National Research Coordinators.

Exhibit 11 Format in Which the Curriculum for Mathematics and Science Is Made Available (Continued)

TIMSS2007 Mathematics & Science 8th Grade

Country	Official Publication Containing the Curriculum		Ministry Notes and Directives		Mandated or Recommended Textbooks		Instructional or Pedagogical Guide		Specifically Developed or Recommended Instructional Activities	
	Mathematics	Science	Mathematics	Science	Mathematics	Science	Mathematics	Science	Mathematics	Science
Algeria	●	●	●	●	○	●	●	○	●	○
Armenia	●	●	●	●	●	●	●	●	●	●
Australia	●	●	●	●	○	○	●	●	●	●
Austria	●	●	●	●	●	●	●	●	●	●
Bahrain	○	○	●	●	●	○	●	○	○	○
Bosnia and Herzegovina	●	●	●	●	○	○	○	○	●	●
Botswana	●	●	●	●	●	●	●	●	●	●
Bulgaria	●	●	●	●	○	○	●	●	●	●
Chinese Taipei	●	●	●	●	●	●	●	●	●	●
Colombia	●	●	●	●	○	○	○	○	○	○
Cyprus	●	○	○	●	●	○	●	●	○	●
Czech Republic	●	●	●	●	○	○	○	●	○	●
Egypt	●	○	●	●	●	○	○	○	○	○
El Salvador	●	●	○	○	●	●	○	○	●	●
England	●	●	○	○	○	○	○	○	●	●
Georgia	●	●	●	●	●	●	○	○	○	○
Ghana	●	●	○	○	●	●	●	●	●	●
Hong Kong SAR	●	●	●	●	●	●	●	●	●	●
Hungary	●	●	○	○	○	○	○	○	○	○
Indonesia	●	●	●	●	●	●	●	●	○	●
Iran, Islamic Rep. of	○	●	●	●	●	●	●	●	○	○
Israel	●	●	●	●	○	●	○	●	●	●
Italy	●	●	●	●	○	○	●	●	○	○
Japan	●	●	●	●	●	●	●	●	●	●
Jordan	●	●	●	●	●	●	●	●	●	●
Kazakhstan	●	●	●	●	●	●	●	●	●	●
Korea, Rep. of	●	●	●	●	●	●	●	●	●	○
Kuwait	●	●	○	●	○	●	●	●	●	●
Lebanon	●	●	●	●	●	○	●	●	●	●
Lithuania	●	●	●	●	●	●	●	○	○	○
Malaysia	●	●	●	●	●	●	●	●	●	●
Malta	●	●	●	●	●	●	●	●	○	○
Mongolia	○	○	●	●	●	●	●	●	○	●
Morocco	○	○	●	○	○	●	●	●	●	○
Netherlands	●	●	●	●	○	○	●	●	●	●
New Zealand	●	●	●	●	○	○	●	●	●	●
Norway	●	●	●	●	○	○	○	○	○	○
Oman	●	●	●	●	○	●	●	●	-	●
Palestinian Nat'l Auth.	●	●	○	○	○	○	●	●	●	●
Qatar	○	○	○	●	●	●	●	●	●	●
Romania	●	●	●	●	●	●	●	●	○	○
Russian Federation	●	●	●	●	●	●	○	○	○	○
Saudi Arabia	●	●	○	●	●	●	●	●	○	●
Scotland	●	●	○	○	○	○	○	●	○	●
Serbia	●	●	●	●	●	●	●	○	●	○
Singapore	●	●	●	●	●	●	●	●	●	●
Slovak Republic	●	●	●	●	●	●	●	●	○	○
Slovenia	●	●	●	●	●	●	○	○	○	○
Sweden	●	●	●	●	○	○	○	○	○	○
Syrian Arab Republic	○	●	○	○	●	●	○	○	○	○
Thailand	●	●	●	●	○	○	●	●	○	●
Tunisia	●	●	●	●	●	●	●	●	●	●
Turkey	●	●	●	●	●	●	●	●	●	●
Ukraine	●	●	●	●	●	●	●	●	●	●
United States	●	●	●	●	●	●	●	●	●	●
Yemen	●	●	●	●	●	●	●	●	○	○
Benchmarking Participants										
Alberta, Canada	●	●	○	○	●	●	○	○	●	●
Basque Country, Spain	●	●	○	●	○	○	●	●	○	○
British Columbia, Canada	●	●	○	○	●	●	●	●	○	○
Dubai, UAE	●	●	●	●	○	●	●	●	○	●
Massachusetts, US	●	●	●	○	○	○	○	○	○	○
Minnesota, US	●	●	●	●	○	○	○	○	○	○
Ontario, Canada	●	●	●	●	●	●	●	○	●	○
Quebec, Canada	●	●	●	●	○	●	○	○	○	○

● Yes ○ No

Data provided by National Research Coordinators.
A dash (–) indicates comparable data are not available.

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2007

Exhibit 12 Methods Used to Evaluate the Implementation of the Curriculum for Mathematics and Science

TIMSS2007 Mathematics & Science 4th Grade

Country	Visits by Inspectors		Research Programs		School Self-evaluation		National or Regional Assessments	
	Mathematics	Science	Mathematics	Science	Mathematics	Science	Mathematics	Science
Algeria	●	●	○	○	○	○	●	●
Armenia	●	●	●	●	●	●	○	○
Australia	○	○	○	○	●	●	●	●
Austria	●	●	●	●	●	●	○	○
Bosnia and Herzegovina	●	●	○	○	●	●	●	●
Botswana	●	●	●	●	●	●	●	○
Bulgaria	●	●	○	○	●	●	○	○
Chinese Taipei	●	●	●	●	●	●	○	○
Colombia	○	○	○	○	●	●	●	●
Cyprus	●	●	●	○	●	●	○	○
Czech Republic	●	●	○	○	●	●	○	○
Denmark	○	○	●	●	●	●	●	●
El Salvador	●	○	●	○	●	●	●	●
England	●	●	●	●	●	●	●	●
Georgia	●	●	●	●	○	○	●	●
Germany	○	○	○	○	●	●	●	○
Ghana	●	●	●	●	○	○	●	●
Hong Kong SAR	●	●	●	●	●	●	●	○
Hungary	○	○	●	●	●	●	●	●
Iran, Islamic Rep. of	●	●	●	●	○	○	●	●
Israel	○	●	●	●	●	●	●	●
Italy	●	●	●	●	●	●	●	●
Japan	●	●	●	●	●	●	●	●
Jordan	●	●	○	○	○	○	●	●
Kazakhstan	●	●	●	●	●	●	●	●
Korea, Rep. of	●	●	●	●	●	●	●	●
Kuwait	●	●	●	●	●	●	○	○
Latvia	●	●	○	○	●	●	●	●
Lithuania	○	○	○	○	●	●	●	●
Malaysia	●	●	●	●	●	●	●	●
Malta	●	●	●	○	●	●	●	●
Mongolia	●	●	●	●	●	●	●	●
Morocco	●	○	○	○	○	○	●	○
Netherlands	-	●	●	●	○	○	●	○
New Zealand	●	●	●	●	●	●	○	○
Norway	○	○	●	●	●	●	●	●
Oman	●	●	●	●	●	●	○	○
Palestinian Nat'l Auth.	●	●	○	○	●	●	●	●
Qatar	●	●	○	○	○	○	●	●
Romania	●	●	○	○	●	○	○	○
Russian Federation	●	●	●	●	●	●	●	●
Scotland	●	●	●	●	●	●	●	●
Serbia	●	●	●	○	●	○	●	○
Singapore	○	○	○	○	●	●	●	●
Slovak Republic	●	●	○	○	●	●	○	○
Slovenia	○	○	●	●	●	●	●	●
Sweden	●	●	●	●	●	●	●	●
Tunisia	●	●	○	○	○	○	●	●
Turkey	●	●	●	●	●	●	●	●
Ukraine	●	●	○	○	●	●	●	●
United States	○	○	●	●	●	●	●	●
Yemen	●	●	●	●	○	○	●	●
Benchmarking Participants								
Alberta, Canada	○	○	●	●	○	○	●	●
Basque Country, Spain	○	○	●	●	●	●	●	●
British Columbia, Canada	○	○	○	○	○	○	●	●
Dubai, UAE	●	●	○	●	○	○	●	○
Massachusetts, US	●	○	●	○	●	●	●	●
Minnesota, US	○	○	●	●	●	●	●	○
Ontario, Canada	○	○	●	○	●	○	●	○
Quebec, Canada	○	○	●	●	○	○	●	●

● Yes ○ No

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2007

Data provided by National Research Coordinators.
A dash (–) indicates comparable data are not available.

Exhibit 12 Methods Used to Evaluate the Implementation of the Curriculum for Mathematics and Science (Continued)

TIMSS2007 Mathematics & Science 8th Grade

Country	Visits by Inspectors		Research Programs		School Self-evaluation		National or Regional Assessments	
	Mathematics	Science	Mathematics	Science	Mathematics	Science	Mathematics	Science
Algeria	●	○	●	●	●	○	○	●
Armenia	●	●	●	●	●	●	○	○
Australia	○	○	○	○	●	●	●	●
Austria	●	●	●	●	●	●	○	○
Bahrain	●	●	●	●	●	●	●	●
Bosnia and Herzegovina	●	●	○	○	●	●	●	●
Botswana	●	●	●	●	●	●	●	●
Bulgaria	●	●	○	○	●	●	○	○
Chinese Taipei	●	●	●	●	●	●	○	○
Colombia	○	○	○	○	●	●	●	●
Cyprus	●	●	○	○	○	○	○	○
Czech Republic	●	●	○	○	●	●	○	○
Egypt	●	○	●	○	●	○	○	○
El Salvador	●	●	●	○	●	●	●	●
England	●	●	●	●	●	●	●	●
Georgia	○	●	●	●	●	○	●	●
Ghana	●	●	●	●	○	○	●	●
Hong Kong SAR	●	●	●	●	●	●	●	○
Hungary	○	○	●	●	●	●	●	●
Indonesia	●	○	●	○	●	●	●	○
Iran, Islamic Rep. of	●	●	●	●	○	○	●	●
Israel	○	●	●	●	●	●	●	●
Italy	●	●	●	●	●	●	●	●
Japan	●	●	●	●	●	●	●	●
Jordan	●	●	○	○	○	○	●	●
Kazakhstan	●	●	●	●	●	●	●	●
Korea, Rep. of	●	●	●	●	●	●	●	●
Kuwait	●	●	●	●	●	●	●	●
Lebanon	●	○	●	○	●	●	○	●
Lithuania	○	○	○	○	●	●	●	●
Malaysia	●	●	●	●	●	●	●	●
Malta	●	●	○	○	●	●	●	○
Mongolia	●	●	●	●	●	●	●	●
Morocco	●	●	○	●	○	○	●	●
Netherlands	●	●	●	●	○	○	●	●
New Zealand	●	●	●	●	●	●	○	○
Norway	○	○	●	●	●	●	●	●
Oman	●	●	○	○	●	●	●	●
Palestinian Nat'l Auth.	●	●	●	●	○	○	●	●
Qatar	●	●	●	●	○	○	●	●
Romania	●	●	○	○	●	●	○	○
Russian Federation	●	●	●	●	●	●	●	●
Saudi Arabia	●	●	●	○	●	●	●	○
Scotland	●	●	●	●	●	●	●	●
Serbia	●	●	●	○	●	○	●	○
Singapore	○	○	○	○	●	●	●	●
Slovak Republic	●	●	●	○	●	●	●	○
Slovenia	○	○	●	●	●	●	●	●
Sweden	●	●	●	●	●	●	●	●
Syrian Arab Republic	●	●	○	●	○	●	●	●
Thailand	●	●	○	○	●	●	●	●
Tunisia	●	●	●	●	○	○	●	○
Turkey	●	●	●	●	●	●	●	●
Ukraine	●	●	○	○	●	●	●	●
United States	○	○	●	●	●	●	●	●
Yemen	●	●	●	●	○	○	●	●
Benchmarking Participants								
Alberta, Canada	○	○	●	●	○	○	●	●
Basque Country, Spain	○	○	●	●	●	●	●	●
British Columbia, Canada	○	○	○	○	○	○	●	●
Dubai, UAE	●	●	○	●	○	○	●	○
Massachusetts, US	●	○	●	○	●	●	●	●
Minnesota, US	○	○	●	●	●	●	●	○
Ontario, Canada	○	○	●	○	●	○	●	○
Quebec, Canada	○	○	●	●	○	○	●	●

● Yes ○ No

Data provided by National Research Coordinators.

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2007

Exhibit 13 Current Requirements for Being a Primary/Elementary Grade Teacher

TIMSS2007 Mathematics & Science 4th Grade

Country	Degree from a Teacher Education Program		Prepracticum During Teacher Education Program		Supervised Practicum in the Field		Passing a Certification Examination		Completion of a Probationary Teaching Period		Completion of a Mentoring or Induction Program	
	Mathematics	Science	Mathematics	Science	Mathematics	Science	Mathematics	Science	Mathematics	Science	Mathematics	Science
Algeria	●	●	●	●	●	●	●	●	●	●	●	●
Armenia	●	●	●	●	●	●	○	○	○	○	○	○
Australia	●	●	●	●	●	●	○	○	●	●	○	○
Austria	●	●	●	●	●	●	●	●	○	○	○	○
Bosnia and Herzegovina	●	●	○	○	●	●	●	●	●	●	○	○
Botswana	○	○	●	●	●	●	○	○	●	●	○	○
Bulgaria	●	●	●	●	●	●	●	●	○	○	○	○
Chinese Taipei	●	●	●	●	●	●	●	○	●	●	○	○
Colombia	●	●	●	●	○	○	○	○	●	●	○	○
Cyprus	●	●	●	○	●	○	○	○	●	●	○	○
Czech Republic	●	●	●	●	○	○	○	○	○	○	○	○
Denmark	●	●	●	●	●	●	●	●	●	●	○	○
El Salvador	●	●	●	●	●	●	●	●	○	○	○	○
England	●	●	●	●	●	●	●	●	●	●	○	○
Georgia	●	●	○	○	○	○	○	○	●	●	○	○
Germany	●	●	●	●	●	●	●	●	●	●	○	○
Ghana	○	○	●	●	●	●	●	●	●	●	●	●
Hong Kong SAR	○	○	○	○	○	○	○	○	○	○	○	○
Hungary	●	●	●	●	○	○	●	●	○	○	○	○
Iran, Islamic Rep. of	●	●	○	○	○	○	○	○	●	●	○	○
Italy	○	○	○	○	○	○	●	●	●	●	○	○
Japan	●	●	●	●	○	○	●	●	●	●	●	●
Jordan	○	○	○	○	○	○	○	○	○	○	○	○
Kazakhstan	●	●	●	●	●	●	●	●	●	●	●	●
Korea, Rep. of	●	●	●	●	●	●	○	○	○	○	○	○
Kuwait	●	●	●	●	●	●	●	●	●	●	○	●
Latvia	●	●	●	●	○	○	○	○	○	○	○	○
Lithuania	●	●	●	●	○	○	○	○	○	○	○	○
Malaysia	○	○	●	●	○	○	●	●	○	○	○	○
Malta	●	●	●	●	●	●	○	○	●	●	●	●
Mongolia	●	●	●	●	●	●	●	●	●	●	●	●
Morocco	○	●	○	●	○	●	●	●	○	●	○	○
Netherlands	●	●	●	●	●	●	●	●	○	○	○	○
New Zealand	○	○	●	●	●	●	○	○	●	●	○	○
Norway	●	●	●	●	○	○	●	●	○	○	○	○
Oman	●	●	●	●	○	○	○	○	○	○	○	○
Palestinian Nat'l Auth.	●	●	○	○	○	○	●	●	○	○	○	○
Qatar	●	●	●	○	●	●	○	○	○	○	○	○
Romania	●	●	●	●	○	○	●	●	●	●	●	●
Russian Federation	●	●	●	●	○	○	●	●	○	○	○	○
Scotland	●	●	●	●	●	●	●	●	●	●	●	●
Serbia	●	●	●	●	●	●	●	●	●	●	○	○
Singapore	○	○	●	●	●	●	●	●	●	●	●	●
Slovak Republic	●	●	●	●	○	○	●	●	○	○	○	○
Slovenia	●	●	●	●	○	○	●	●	●	●	○	○
Sweden	●	●	●	●	●	●	○	○	○	○	○	○
Tunisia	●	●	●	●	●	●	●	●	●	●	○	●
Turkey	●	●	●	●	●	●	●	●	●	●	●	●
Ukraine	●	●	●	●	●	●	●	●	○	○	○	○
Yemen	●	●	●	●	○	○	○	○	○	○	○	○
Benchmarking Participants												
Alberta, Canada	●	●	○	●	●	●	○	○	●	●	○	○
Basque Country, Spain	●	●	●	●	●	●	○	○	●	○	○	○
British Columbia, Canada	●	●	●	●	●	●	○	○	●	○	○	○
Dubai, UAE	●	○	●	●	●	●	●	●	○	○	●	●
Massachusetts, US	●	○	●	○	●	○	●	●	○	○	○	○
Minnesota, US	●	●	○	○	●	●	●	●	●	●	○	○
Ontario, Canada	●	●	●	●	●	●	○	○	○	○	●	●
Quebec, Canada	●	●	●	●	●	●	○	○	○	○	○	○

● Yes ○ No

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2007

Data provided by National Research Coordinators.

Exhibit 14 Current Requirements for Being a Middle/Lower Secondary Grade Teacher

TIMSS2007 Mathematics & Science 8th Grade

Country	Degree from a Teacher Education Program		Prepracticum During Teacher Education Program		Supervised Practicum in the Field		Passing a Certification Examination		Completion of a Probationary Teaching Period		Completion of a Mentoring or Induction Program	
	Mathematics	Science	Mathematics	Science	Mathematics	Science	Mathematics	Science	Mathematics	Science	Mathematics	Science
Algeria	●	●	●	●	●	●	●	●	●	●	○	○
Armenia	●	●	●	●	●	●	○	○	○	○	○	○
Australia	●	●	●	●	●	●	○	○	●	●	○	○
Austria	●	●	●	●	●	●	●	●	●	●	○	●
Bahrain	●	●	●	●	●	●	●	●	●	●	○	○
Bosnia and Herzegovina	●	●	○	○	●	●	●	●	●	●	○	○
Botswana	○	○	●	●	●	●	○	○	●	●	○	○
Bulgaria	●	●	●	●	●	●	●	●	○	○	○	○
Chinese Taipei	●	●	●	●	●	●	●	●	●	●	○	○
Colombia	●	●	○	○	●	●	○	○	●	●	○	○
Cyprus	●	●	●	○	●	○	●	○	●	●	●	●
Czech Republic	●	●	●	●	○	○	○	○	○	○	○	○
Egypt	●	●	○	○	●	○	○	●	○	○	○	○
El Salvador	●	●	●	●	●	●	●	●	○	○	○	○
England	●	●	●	●	●	●	●	●	●	●	○	○
Georgia	○	●	○	○	○	○	○	○	○	○	○	○
Ghana	●	●	●	●	●	●	●	●	●	●	●	●
Hong Kong SAR	○	○	○	○	○	○	○	○	○	○	○	○
Hungary	●	●	●	●	○	○	●	●	○	○	○	○
Indonesia	●	●	●	●	●	○	●	○	●	○	●	○
Iran, Islamic Rep. of	●	●	○	○	○	○	○	○	●	●	○	○
Israel	●	●	●	●	●	●	○	○	●	●	●	●
Italy	○	○	○	○	○	○	●	●	●	●	○	○
Japan	●	●	●	●	○	○	●	●	●	●	●	●
Jordan	●	●	○	○	○	○	○	○	○	○	○	○
Kazakhstan	●	●	●	●	●	●	●	●	●	●	●	●
Korea, Rep. of	●	●	●	●	●	●	○	○	○	○	○	○
Kuwait	●	●	●	●	●	●	●	●	●	●	●	●
Lebanon	○	●	○	○	○	○	●	●	●	●	○	●
Lithuania	●	●	●	●	○	○	○	○	○	○	○	○
Malaysia	●	●	●	●	●	●	●	●	●	●	○	○
Malta	●	●	●	●	●	●	○	○	●	●	○	○
Mongolia	●	●	●	●	●	○	●	●	●	●	●	●
Morocco	○	●	○	●	○	●	●	●	○	●	○	●
Netherlands	●	●	●	●	●	●	●	●	○	○	○	○
New Zealand	○	○	●	●	●	●	○	○	●	●	○	○
Norway	●	●	●	●	○	○	●	●	○	○	○	○
Oman	●	●	●	●	○	○	○	○	○	○	○	○
Palestinian Nat'l Auth.	●	●	○	○	○	○	●	●	○	○	○	○
Qatar	●	●	●	●	●	●	○	○	○	○	○	○
Romania	●	●	●	●	○	○	●	●	●	●	●	●
Russian Federation	●	●	●	●	●	●	●	●	○	○	○	○
Saudi Arabia	●	●	○	●	●	●	●	●	●	●	○	○
Scotland	●	●	●	●	●	●	●	●	●	●	●	●
Serbia	●	●	●	○	●	●	●	●	●	○	●	○
Singapore	○	○	●	●	●	●	●	●	●	●	●	●
Slovak Republic	●	●	●	●	○	○	●	●	○	○	○	○
Slovenia	●	●	●	●	○	○	●	●	●	●	○	○
Sweden	●	●	●	●	●	●	○	○	○	○	○	○
Syrian Arab Republic	●	○	●	○	●	○	○	●	○	○	●	○
Thailand	●	●	○	○	○	○	○	○	○	○	○	○
Tunisia	●	●	●	●	●	●	●	●	●	●	●	●
Turkey	●	●	●	●	●	●	●	●	●	●	●	●
Ukraine	●	●	●	●	●	●	●	●	○	○	○	○
United States	●	●	●	●	●	●	●	●	●	●	○	○
Yemen	●	●	●	●	○	○	○	○	○	○	○	○
Benchmarking Participants												
Alberta, Canada	●	●	○	○	●	●	○	○	●	●	○	○
Basque Country, Spain	●	●	●	●	●	●	○	○	●	○	○	○
British Columbia, Canada	●	●	●	●	●	●	○	○	●	○	○	○
Dubai, UAE	●	○	●	●	●	●	●	●	○	○	●	●
Massachusetts, US	●	○	●	○	●	○	●	●	○	○	○	○
Minnesota, US	●	●	○	○	●	●	●	●	○	●	○	○
Ontario, Canada	●	●	●	●	●	●	○	○	○	●	●	○
Quebec, Canada	●	●	●	●	●	●	○	○	○	○	○	○

Data provided by National Research Coordinators.

● Yes ○ No

SOURCE: IEA's Trends in International Mathematics and Science Study (TIMSS) 2007

Summary

The *TIMSS 2007 Encyclopedia* provides an opportunity to compare and contrast the common and unique features of the country contexts and curricular goals used in teaching mathematics and science around the world. The qualitative nature of the chapters provides information about how the TIMSS 2007 countries and their education systems differ from one another in many important ways. However, there also are important similarities in the curricula across countries. These differences and similarities are important to note when making international comparisons and while reading the chapters.

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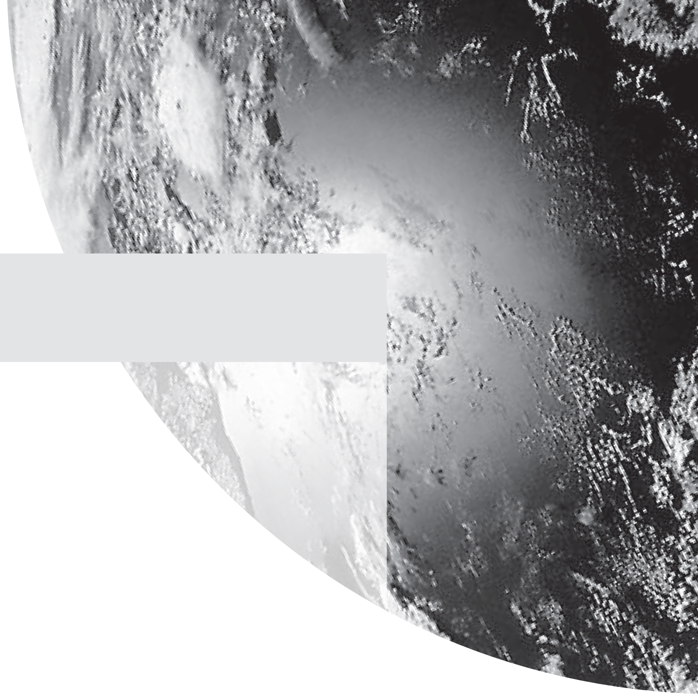

Algeria

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Ministry of National Education

Introduction

Overview of Education System

Compulsory and secondary education are the responsibility of the Ministry of National Education. Higher Education is placed under the authority of the Ministry of Higher Education and Scientific Research. Professional training and teaching of crafts are the responsibility of the Ministry of Vocational Training.

The curriculum has been developed by a new organization, the National Commission for Programs, an independent scientific and pedagogical institution.[1] It is composed of executives of the education sector, inspectors, and higher education teachers. Approval of the curriculum is made by decree of the Minister for State Education.

The Algerian education system is composed of two subsystems placed under the administrative and pedagogical authority of the Ministry of National Education. It includes the following.[2]

- Basic compulsory education is 9 years, composed of two main phases—primary (5 years) and intermediate education (4 years). Children can begin school at age 6. At the end of both primary and intermediate (middle) school, there is the BEM or school certificate examination.
- Secondary education is 3 years.

In addition to these two large subsystems, there is a noncompulsory preschool phase for children age 4 (to be extended to children age 5 as a result of the reform of the education system) carried out in preparatory classes in some primary schools, kindergartens, or infant classes. Although preschool is under the authority of the Ministry of National Education, the municipalities, as well as some public economic enterprises and the private sector, are in charge of teaching preschool.

Education reform aims essentially at improving teaching quality and consequently, at student outcomes. Thus, it will be necessary to improve the entire educational processes including the following.[3]

- Teaching methods and programs
- Schoolbooks and other didactic support
- Qualifications of pedagogic and administrative staff
- Reformation of the education administration
- Reorganization of schools
- Support for scholarship.

To improve student outcomes, it was necessary to set up concrete measurable objectives, including the following.[4]

- Enable 90 percent of entering primary school students to reach the end of the compulsory education cycle
- Enable 75 percent of fourth year students to enter the upper level schools (i.e., high schools or postcompulsory education)
- Direct the majority of intermediate school students to secondary schools
- Direct 50 percent of the remaining students toward vocational training, of which 60 percent will study vocational training and 40 percent will study vocational teaching
- Enable 70 percent of students to succeed at the baccalaureate examination.

The pedagogy reform aims to improve teaching quality and represents a new vision of education, which marks epistemological and methodological changes and a departure from the past. This new vision defines itself by adopting the competency approach as a global dynamic of pedagogical reform.

The pedagogy reform consists of gathering all the forces at the many levels, including the teaching curriculum, pedagogical methods, textbooks and other pedagogical means, assessment modes, class management, school management, etc. Also it is the basis for the reform of the national system of vocational teaching and training.

Jobs and technology are constantly evolving, which results in increased demand for qualifications and modification of training modes. This reform requires revision of existing organizations, the introduction and modernization of teaching methods, and the development of didactic tools and training contents.

In particular, the curriculum and textbooks are a primary focus. The change in the teaching curriculum consists of the following.[5]

- More accuracy in teaching content in relation to the objectives established in the reform
- Rehabilitation of some disciplinary fields by reinforcing Arabic as the national official language and making it an efficient instrument for teaching and training; promoting Tamazight teaching (Tamazight is one of the national languages); teaching foreign languages; promoting an educational dimension necessary for the preparation of children as citizens; rehabilitating the history and philosophy of teaching; rehabilitating physical education and sports and promoting

art education; and using universal symbols in science and technology and introducing some concepts of scientific terminology in textbooks.

Language and Population

Arabic is the official language in Algeria. It also is the language of teaching in the primary, intermediate, and secondary cycles. Tamazight also is recognized as a national language and is taught, along with French, English, Spanish, and German. Mathematics and the sciences are taught in Arabic.

Overarching Policies Related to Education and the Curriculum for Mathematics and Science

Mathematics contributes to the development of students' intellectual capacities and personalities and also helps students acquire conceptual and procedural tools. With the development of technologies such as the computer and the calculator, mathematics is present in the social, economic, communication, and cultural environment of man. Mathematics helps students acquire competencies in other domains in school or life and helps students learn to communicate. Mathematics has two goals: one is formative and cultural, and the other is utilitarian.

Scientific and technological education, which integrates the different domains of science and technology, by its nature leads to discovery of the environment, analysis of phenomena, and use of technology. It also helps the student construct knowledge in a continuous and progressive way and acquire scientific knowledge as the basis of competencies. This leads to students acquiring key tools that contribute to understanding and mastering the world around them. It also develops the features of the scientific mind: objectivity, reasoning, presentation of arguments, curiosity, and the critical mind.

The Mathematics Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Mathematics Through Eighth Grade

The program of mathematics in the **fourth year of primary school** emphasizes problem solving, which teaches students to research and consists of the following competencies.[6]

- Solve addition and multiplication problems and the problems related to proportionality in the domain of the numbers lower than 100,000
- Solve geometric problems related to location, representation, reproduction, construction, reduction, and enlarging
- Solve problems in the domain of measurement, correctly using the instruments of geometry and suitable units, and solve problems in the domain of simple geometric figures using the calculation of perimeter and area.

The competencies expected in the **second year of middle school**[7] include the following.

- Solve problems using simple equations in the domain of fractions and rational numbers
- Solve problems using proportionality, size, and the organization of data

- Construct simple figures using the instruments of drawing, indicate lines of symmetry, and explain the properties of these figures.

The Science Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Science Through Eighth Grade

The competencies of the **fourth year of primary school** and the **second year of middle school** comprise the following dimensions.[8]

- *Physical and chemical dimension*: discover the properties of matter and the phenomena of the nonliving natural world
- *Biological dimension*: identify the life phenomena of man and of living beings and their relations to the environment
- *Technological dimension*: help the learner to be open minded to the available technologies used around the world
- *Computer dimension*: learn to use the computer in relation to the development of a project.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Time

The time allocated for mathematics teaching in the fourth year is 5 hours per week,[9] which is 16 percent of the total instructional time. Sciences (scientific and technological education) account for 6 percent of the total instructional time, which is 2 hours per week.

In the eighth year, students have 5 hours of mathematics, which is 17 percent of the total instructional time, 2 hours of natural science, and 2 hours of physics[10] (physical sciences and technology). Science accounts for 13 percent of the total instructional time.

Instructional Materials, Equipment, and Laboratories

The National Center of Pedagogical Equipment, which is under the national supervision of the Minister of Education, is responsible for equipping all schools with materials and laboratories.

Use of Technology

Schools must prepare children to live in a world where all kinds of activities are centered on information and communication technology. Technologies will bring about changes in the following areas.[11]

- The content of teachers' training
- The curriculum
- Didactic devices
- The relationship between the teacher and learner and pedagogical methods (more autonomy for the learner and a larger range of training and self-evaluation).

Teachers and Teacher Education

Education and Training for Fourth and Eighth Grade Mathematics and Science Teachers

As a result of the new organization of primary school, there is a new framework for the preservice training of teachers. Those who have passed the examination and hold the baccalaureate degree are admitted for 3 years of specific training in institutes designed for this purpose. These institutes are under the authority of the Ministry of National Education and the Ministry of Higher Education and Scientific Research.

The preservice training of middle and secondary school teachers is completed in superior training schools. The middle school teachers' training is 4 years and the secondary school teachers' training is 5 years.

Teacher Professional Development in Mathematics, Science, and Technology

Professional development has a varied multiyear curriculum. Motivating mechanisms are established to promote teachers and new rules are set up in order to prepare secondary school teachers. The assigned objectives can be summarized as follows.[12]

- The leveling of the skills of professional development trainers and managerial staff leading to universal competency standards
- Organization of training for the trainers who hold a Professional Aptitude Certificate to become superior technicians
- Establishment of a recruitment plan for the preservice training and trainers' management. The trainers' recruitment policy must be oriented towards the real needs of the education sector by offering funding for specialties (building, crafts) and by setting up a policy of valuing existing competencies
- Improvement of the qualification standards of those who train teachers
- Improvement of the pedagogical and administrative staff's status
- Development of the tutoring capacity of training related to crafts and manual work
- Development of the managerial capacities of the vocational training of administrative staff in vocational schools.

Examinations and Assessments

National or Regional Examinations

The new assessment approach aims at improving, in a qualitative and significant manner, the existing mechanism and not systematically deviating from what was previously done. It consists of the following.

- Supporting and reinforcing practices and modes that are still in use
- Correcting the assessment system to give it the framework that guarantees better results

It mainly is characterized by the following.[13]

- The adaptation of assessment practices to the new curricular vision, which is based on the competencies approach
- The importance given to formative assessment and the pedagogical remedial approach, which helps as many students as possible overcome their weaknesses and progress through remedial activities to reach targeted objectives
- An increase in the frequency of assessment and its systematic use
- Prerequisites to check whether students qualify to pass from one level to the next and the reinforcement of school results.

The assessment of students' work is done through continuous, year-long monitoring during school. At the end of the cycles of teaching, there is a national examination that measures the degree of mastery of the fundamental languages, according to the levels of expertise assigned to different cycles.

At the end of the primary education cycle, there is a national examination in Arabic, mathematics, and French.[14] At the end of middle or intermediate education there also is a national examination, the BEM[15, 16] in Arabic, mathematics, the sciences of nature and life, French, and English. There also is a final examination at the end of secondary education.

Other Tests

As a result of the reform of the education system a permanent practice for the follow-up and assessment of students has been in place since the 2003–2004 school year. The goal of this practice is to follow the evolution of the quality of teaching at its different stages—primary, middle, and secondary—through the assessment of students, particularly at the fundamental languages level. This practice monitors all actions undertaken and leads to corrective feedback that will orient the new programs and processes of teaching toward the objectives that are already set.

Monitoring Individual Student Progress

Emphasis is placed on the use of the results of the official examinations and continuous assessment, which are the subject of a systematic analysis at the central administration level, as well at the departmental and school level. These results are the basis of necessary measures to improve school results.

Grade Promotion and Retention Policies

Promotion from one year to the next is based on educational considerations and on the decision of the teachers or professors. The decision to promote students is based on the conventional average of a score of 5 on a 10-point grading system (10 points being the highest grade) for primary education and a score of 10 on a 20-point grading system (20 points being the highest grade) for middle and secondary education.[17]

Students are admitted to the middle cycle only if they have succeeded on the examination at the end of primary education and they have an average equal or superior to 5 out of 10 points, which is obtained by taking the mean of the students' general average on the examination and the yearly average of the continuous assessment.[18] If a student fails, he or she receives a second chance at the examination.

Access to secondary education is based on the success of students on the examination at the middle or intermediate level (BEM) or by obtaining an admission average equal or superior to 10 out of 20 points. This is obtained by taking the mean of the average score on the BEM and the yearly average of the continuous assessment.[19]

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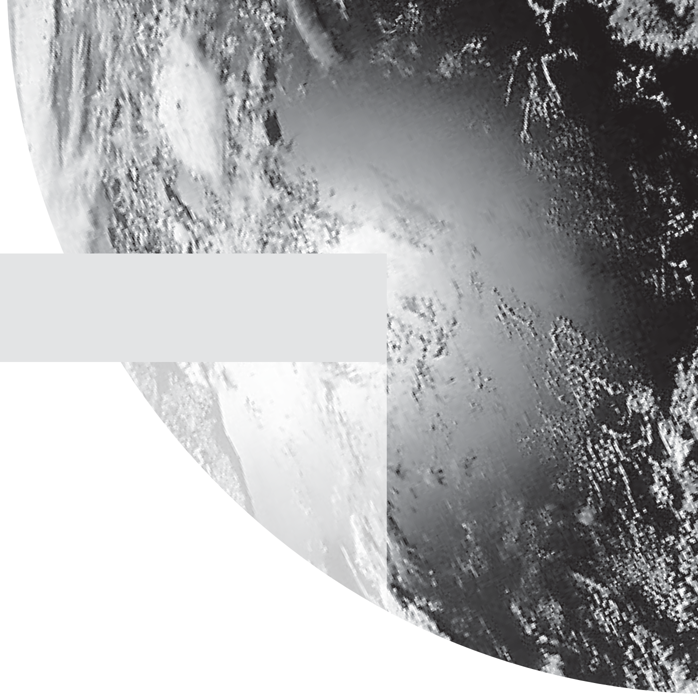

Armenia

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Introduction

Overview of Education System

Article 35 of the first Constitution of the Republic of Armenia,[1] adopted in 1995, proclaimed that every citizen has the right to an education, education is free of charge in the state secondary educational institutions, and every citizen has the right to receive a professional education free of charge on a competitive basis in state professional education institutions. The National Assembly of the Republic of Armenia adopted the Law on Education[2] on April 14, 1999, which has guided the reform of the system.

The education system of the Republic of Armenia covers the following.

- State education standards and educational programs at the different levels and directions ensuring educational continuity
- Network of various types of education institutions implementing those programs
- System of education management bodies and their subordinate entities and institutions.

The education system of Armenia includes the following.

- Preschool education
- General secondary education comprised of primary education, middle or basic education, and high school
- Preliminary vocational, middle level vocational, and higher professional education
- Postgraduate education, specialist training, and qualification improvement institutions
- Education assessment and institutions delivering education services.

Preschool education has three main goals: promotion and strengthening of a child's physical, moral, and mental health; harmonic development and upbringing of preschool children; and preparation for primary education.

Preschool education is an integrated process with the following goals.

- Development of the preschool child, appropriate to his or her inclinations, capacities, abilities, and mental and physical needs
- Formation of the preschool child's basic behavioral skills.

The state has the central role in implementing preschool education programs for families by committing itself to creating conditions for organizing the child's development and care in families. The state also establishes preschool institutions to support families, including nurseries (ages 2–3) and kindergartens (ages 3–6).

In May 2004, the Government of Armenia approved the General Education National Curriculum Framework[3] and in June 2004, the Secondary Education State Standard. According to the General Education National Curriculum Framework, general education in Armenia is implemented in a 12-year general school (transition to a 12-year education system began in the 2006–2007 academic year) through the three following sequential levels.

- *Primary school*: 4 years (grades 1–4)
- *Middle school*: 5 years (grades 5–9)
- *High school*: 3 years (grades 10–12).

At present, there are 1,329 state general schools, of which 10 are primary schools, 151 are middle or basic schools, and 1,168 are secondary schools. There also are 34 colleges and 14 vocational schools in Armenia. In addition to state schools, there are 41 private schools in the country with 6,541 students. Private schools do not receive financing from the state.

In general education, 465,403 students are enrolled. In recent years, the number of students has continuously declined and in 2007, enrollment dropped by 20.2 percent, as compared to 1991 (583,797 students).

Higher education in the Republic of Armenia is provided through bachelor's and master's degree programs at both state and private education institutions. These programs may be in the form of stationary or distance education and may be free or tuition-based. Parallel to this, there also is a certified specialist education system.

There are 22 state higher education institutions and 11 branches in Armenia. There also are 72 nonstate higher education institutions, of which 34 are accredited, and 12 have accredited specializations. At present, Armenia prepares specialists in approximately 200 specializations. There are 73,716 students enrolled in state higher education institutions, of which 15,968 are in the distance learning system (as of April 2007), and 25,416 students in nonstate higher education institutions. Of these students, 1,668 are studying to receive their master's degrees.

Language and Population

Armenian is the official language of Armenia and the official language of instruction.[4] In 2007, Armenia's population was 98 percent Armenian.

The Mathematics Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Mathematics Through Eighth Grade

The mathematics curriculum in primary school, **grades 1–4**, includes the following main topics.

- Arithmetic operations
- Natural numbers
- Adding and subtracting natural numbers
- Speed, time, and distance
- Multiplication and division of natural numbers
- Algebraic expressions
- Fractions
- Geometric shapes.

The mathematics curriculum in **grades 5 and 6** includes the following main topics.

- Natural numbers
- Operations with fractions
- Angles and their measurement
- Percents
- Rational numbers.

In **grades 7–9**, mathematics is divided into algebra and geometry.

- *Algebra*: addition and subtraction, multiplication and division, powers, logical algebra, figure algebra, equations with a single variable, binomials, square roots, quadratic polynomials, linear equation systems, powers with whole and fraction indices, sequences, and functions.
- *Geometry*: triangles, parallel lines, sides and angles of triangles, geometric constructions, quadrilaterals, circumference and circles, area of a figure, similar triangles, similar figures, and vectors.

The Science Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Science Through Eighth Grade

Science in primary school, **grades 1–4**, is divided into two subjects: nature and natural science. The task of these subjects is to help students do the following.

- Learn the basics of investigations in science
- Learn nature's systems
- Learn nature's processes
- Understand the diversity and unity of nature
- Understand the importance of achievements in the natural sciences in everyday life

- Understand the necessity of preserving the environment and one's health.

The following is the basis for structuring the science content.

- Basics of research work
- Nature's systems
- Nature's processes
- Humans and the environment
- Basics of research activities.

Science in **grades 7–9** includes the following subjects: geography, geography of Armenia, physics, chemistry, and biology. The curriculum of these subjects includes the following topics.

- *Physics***:** the physical body and simple measurements, the body's movement and interaction, work and power and simple mechanisms, the structure of materials, pressure, kinematics, dynamics, mechanical vibrations and waves, heat and temperature, electric phenomena, electromagnetic phenomena, optical phenomena, and the structure of the atomic nucleus.
- *Chemistry***:** general concepts of chemistry; oxygen, oxides, and combustion; hydrogen, acids, and salts; water, solutions, and bases; basic groups of inorganic compounds; the periodic table of chemical elements; chemical bond and structure of a molecule; electrolytic dissociation; subgroups of halogens, oxygens, nitrogens, and carbons; and organic compounds.
- *Geography***:** the Earth and its geographical envelope of gases; continents and oceans; geography of Armenia (relief, climate, nature, rivers, and lakes); world and states (nature, population, and economy); Republic of Armenia (population, economy); and the Republic of Nagorny Kharabakh (nature, population, and economy).
- *Biology*: lower plants (algae); higher plants (moss, ferns, gymnosperms, and angiosperms); bacteria and fungi; protozoan (infuzoria, sporozoa), metazoan (types of coelenterate, worms, molluscoid, arthropod); chordates (fish, amphibian, reptile, birds, mammalians); humans (blood, blood circulation, immune system); respiratory, digestive, excretory, nervous, musculoskeletal, and endocrine systems; the reproductive system; organs of sense and skin; and metabolism.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Time

The total instructional time students spend in school at fourth grade is 23 hours per week, of which 20 percent is devoted to mathematics and 10 percent is devoted to science. In grade 8, there are 27 hours of instructional time per week, with 20 percent spent on mathematics. In eighth grade, science is taught as separate subjects, with 6 percent of instructional time spent on each subject—geography, physics, chemistry, and biology. Exhibit 1 shows the number of class periods per week students receive instruction in each of the different science subjects in grades 1 to 9.

Exhibit 1 Number of Class Periods Per Week Science Subjects Are Taught in Armenia

Subjects	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Grade 9
Nature	1	1	1	1	1	1			
Natural Science	1	1	1	2	2	1			
Geography						1	1	1	1
Geography of Armenia								1	1
Physics							2	2	2
Chemistry							1	2	2
Biology							2	2	2

Teachers and Teacher Education

Teacher Professional Development in Mathematics, Science, and Technology

Currently, there are 43,113 teachers who work in general education schools. (The number of teachers has declined compared to previous years.) Of this number, the majority (57%) of teachers are between 40–60 years old, 25.3 percent are between 30–40 years old, and 15.2 percent are under 30. Of the total number of teachers, 2.5 percent are at retirement age.

Teachers mainly have higher education (colleges and universities) or middle level professional education (professional qualifications offered after general secondary education). Of the total number of teachers, 74.4 percent have a higher pedagogical education background, 5.8 percent have a higher nonpedagogical education, 11.2 percent have a middle level professional education, 4.7 percent have a middle level nonprofessional education, and 3.9 percent of all teachers did not complete higher education.

Teacher Professional Development in Mathematics, Science, and Technology

A key factor in the successful reform of the education system in Armenia is the professional development of teachers. Teachers are the core players in the general education reform and thus, their continuous professional development is vitally important.

Extensive teacher training courses, conducted since 2005, involve teachers in the reform by making them leaders in the process. To ensure effective use of the new curriculum, syllabi, standards, and assessment tools, teachers receive subject-based training, following the sequence of syllabi development. Training is conducted using the Training of Trainers model (i.e., a core group of central trainers is trained by international experts who, in turn, train local trainers, and the latter group trains teachers). School-based training is conducted by 52 school centers that are selected from all *marzes,* or regions of Armenia, and the National Institute of Education and its 11 *marz* branches. Approximately 4,100 teachers have participated in training courses in different subjects.

In total, 200–300 trainers have been trained for each subject in the teacher training courses, which allows for further expansion of the training process.

Previously in Armenia, the emphasis in teaching students was on mastering facts and reproducing information. Nowadays, it is more important to learn how to gain knowledge, obtain practical skills, and develop competencies and learn how to use them. This encourages effective cooperation between students to accomplish a shared goal, and develops students' capability to organize the learning process independently. In the educational process, this goal may be achieved using both interactive and cooperative learning methods. To implement these cooperative learning methods, three 3-day seminars on the application of cooperative learning methods are offered to teachers. To date, approximately 530 teachers have participated in these training sessions.

Examinations and Assessments

National or Regional Examinations

Since 2003, the assessment and testing system in Armenia has undergone major reforms. Prior to these reforms, testing was not used as a method of assessment and students and teachers were unfamiliar with the format of tests. Under the new reform, teachers are being trained to use new assessment techniques in the classroom and to align their teaching with the new assessment system. New examinations have also been implemented as a result.[5]

At the end of primary school, students sit for examinations in the Armenian language and mathematics. At the end of basic school (currently grade 9), students are awarded the Certificate of Basic Education. This is a diploma summarizing achievement, as indicated by the student's grade point average, in each of the subjects studied. However, in some subjects, an additional summative examination is given, and the results are recorded separately on the certificate. The examination subjects are the Armenian language, mathematics, and a foreign language.

At the end of grade 11, students take examinations in five subjects: Armenian language and literature, mathematics, Armenian history, a science subject of the student's choice, and a foreign language.

In 2007, the Assessment and Testing Center[6] first administered the combined examination of the Armenian language and literature as a *Matura* Examination (school-leaving examination) and centralized the examination for admittance to universities. In 2008, it will test three subjects: mathematics, Armenian language and literature, and foreign language. In 2009, it also will test in science (four subjects) and the history of Armenia.

Monitoring Individual Student Progress

Throughout the three phases of general education, responsibility for the assessment of students is delegated, with few exceptions, to schools and teachers. Teachers have, by tradition, been free to choose their methods of assessment and to set their own standards.

In grade 1, a brief, evaluative written or oral description of the student's learning activities, style of work, communication and cooperation skills, attitudes, and development of learning dynamics is made. In grades 2 to 11, the most commonly used assessment methods are personal inquiry (i.e., questioning and oral tests), monitoring assignments (i.e., written tasks set specifically for the purpose of assessment), and homework tasks. Typically, secondary school teachers will set monitoring assignments or projects each year in mathematics, natural science, the Armenian language, and a foreign language. In other subjects (e.g., history and geography), oral tests are used. All forms of assessment are graded on a 5-point scale.

Suggested Readings

Central Statistical Bureau of Armenia: http://www.armstat.am

Government of Republic of Armenia: http://www.gov.am

Ministry of Education and Science Republic of Armenia: http://www.edu.am

The Assessment and Testing Center: http://www.atc.am

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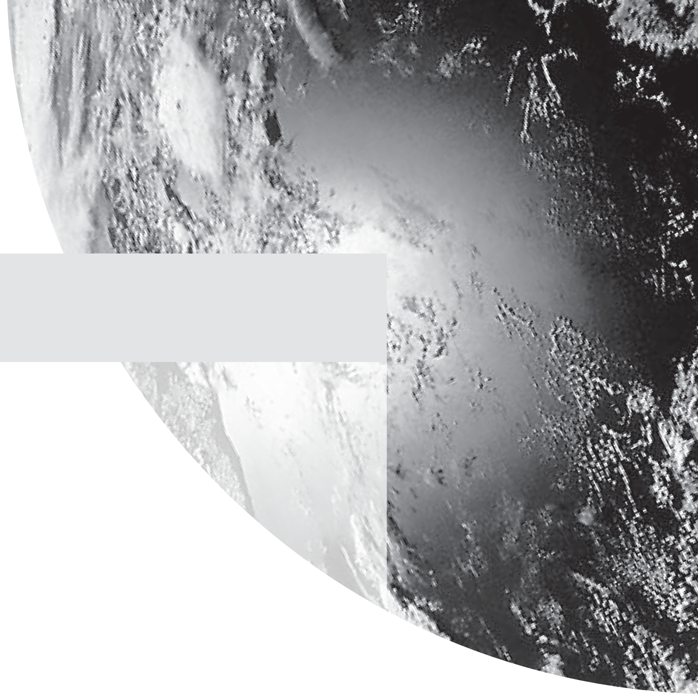

Australia

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Introduction

Overview of Education System

Australia does not have a single national education system. The states and territories are each responsible for their own educational administrations, although the overall structures are similar. Collaboration on matters of policy takes place in the Council of Ministers of Education, and the role of the federal government has increased during the past two decades. State education departments recruit and appoint the teachers in government schools, supply buildings, equipment, and materials and provide limited discretionary funding for use by schools. In most jurisdictions, some responsibility for administration, staffing, and curriculum has been passed on to regional offices and schools. The extent of this varies between jurisdictions. It is important to note that one third (33%) of school students attend nongovernment schools.

Although there is no national school curriculum, there is wide agreement about the content that should be covered in schooling. Within the states, central authorities specify the curriculum and standards framework, but schools have autonomy in deciding curriculum details, textbooks, and teaching methodology. This situation applies particularly to the primary and lower secondary levels. Curriculum for grades 11 and 12 is specified by state authorities responsible for examining and certifying student achievement (for both government and nongovernment schools).

Education is compulsory from ages 6 to 16, with several states extending the age of compulsory schooling. Children generally attend preschool or kindergarten part time for 1 or 2 years before starting school. Preschools are usually run by local councils, community groups, or private organizations except in the northern territory and Queensland where they are run by the territory and state governments, respectively. Preschool is offered to children aged 3 to 5 years old, although attendance numbers vary widely (from 50% in New South Wales to 93% in Victoria). The focus of preschool is primarily social.

Most children start primary school at age 5 and continue to grade 6 or 7 (depending on the state), thus completing primary school at the age of 11 or 12. Secondary education is provided for either 5 or 6 years, depending on the length of primary education in the state. The first 2 years of secondary school typically consist of a general program followed by all students. In subsequent years, a basic core of subjects is supplemented with optional subjects available to students. In the final 2 years of secondary school, students have the opportunity to specialize and a range of elective studies is provided, from which students choose five or six. It is common for mathematics to be provided at different levels and for students to choose the level appropriate to their future plans.

One of the most marked changes during the 1980s was an increase in the percentage of students who remained to complete secondary school. The percentage of students who started secondary school and remained until the final year rose from 35 percent in 1980 to 77 percent in 1993. However, in 2006, the percentage declined to 75 percent.[1]

Most government schools are comprehensive and coeducational. Tax revenues provide almost all the financial resources for the operation of government schools. Although parents are not officially required to pay fees for students to attend government schools, many schools seek voluntary contributions from parents and raise funds from other local sources. There are a small number of selective-entry secondary schools in some states, and in two jurisdictions, the final 2 years of schooling take place in separate senior secondary colleges.

There is no common national policy on ability grouping, streaming, tracking, or setting of students in Australia. Streaming is a school-based decision and is not officially promoted in any state. Some schools choose to stream students according to their ability, and some have special enrichment and remedial programs for groups of students. In primary schools, there is almost no systematic grouping, and most classes are heterogeneous in their composition.

Up to grade 10 in secondary school, grouping practices vary between schools and between states. In two states and in some schools in other states, a unit curriculum system operates under which students choose semester length units within certain requirements (including specified studies in mathematics and science). This practice can result in de facto ability grouping through the combinations of units chosen, and some students choose more science or mathematics than the minimum required. Other schools provide enrichment studies in mathematics and physical sciences for those students likely to pursue studies in the sciences (especially in grade 10). In at least one state, setting in mathematics is common.

Language and Population

English remains the language of instruction in education. The Australian population is mainly from a European background, although recent immigration has produced a greater ethnic and cultural diversity. Based on the 2006 national census, 22 percent of the Australian population was born overseas, and 21 percent of the population speak a language other than English at home. According to this census, just over 2 percent of the population (almost 20 million people) identified themselves as having an indigenous origin.[2] About 4 percent of Australian school students are indigenous (aboriginal or a Torres Strait Islander), and some of them live in isolated communities.

Emphasis on Mathematics and Science

The Australian Government is providing a total of $38.8 million over 7 years for improvements recommended by the independent committee Review of Teaching and Teacher Education. The review concluded that,

> Developing greater scientific awareness in the general population, inspiring more young people to take up careers that depend on excellence in science, technology and mathematics, and building a culture of innovation in Australia's schools are of the utmost importance if Australia and its people are to be successful in a global world.[3]

As a result of this review, the government developed Boosting Innovation, Science, Technology, and Mathematics Teaching (BISTMT), a program that fosters innovation in schools, develops the capacities of students in science, mathematics, and technology, and promotes high-caliber teaching that engages students. It is hoped that this program will encourage more young people to pursue careers in these areas.

Under the umbrella of BISTMT, the Australian government committed to innovation in and the improvement of science, mathematics, and technology education in Australian schools under the Australian School Innovation in Science, Technology, and Mathematics Program. Funding has been made available over 7 years by the Australian government for projects in schools that will encourage innovation in schools and students, improve teaching in these areas, and attract high-quality graduates in the fields of science, technology, and mathematics to the teaching profession.

Overarching Policies Related to Education and the Curriculum for Mathematics and Science

In 1997, the Australian Government and state education ministers agreed to a National Literacy and Numeracy Plan which focused on the crucial early years. Part of this plan is for teachers to conduct early student assessments in literacy and numeracy and to implement intervention strategies for students having difficulty in these areas. National benchmarks are now in place in grades 3, 5, and 7.

The National Goals for Schooling in the 21st Century identify mathematics and science as key learning areas.[4] In 2003, as a means of achieving greater national consistency in curriculum outcomes across the eight states and territories, the Ministerial Council on Education, Employment, Training, and Youth Affairs requested that the statements of learning be developed in English, mathematics, science, and civics and citizenship. The statements of learning describe essential skills, knowledge, understandings, and capacities that all young Australians should have the opportunity to learn by the end of grades 3, 5, 7, and 9. The statements and their professional elaborations (related to the civics and citizenships area) are intended to be used by state and territory departments or curriculum authorities (their primary audience) to guide the future development of relevant curriculum documents.

The Australian government has provided funding for a number of projects that aim to improve the awareness and importance of science, as well as improve the resources available to teachers at both primary and secondary schools.[5] One project, Backing Australia's Ability—Building Our Future through Science and Innovation, has funding for $5.3 billion over 7 years. The project represents a commitment to pursuing excellence in research, science, and technology in order to promote the generation and application of new ideas, and develop and retain skills.[6] Within this project, the Science Connections Program was developed. Its main objective is to increase awareness of the role that science, technology, and innovation play in ensuring the well-being of our society and the environmentally sustainable growth of our economy.[7] Another of these projects is the Science Education Assessment Resource, which is an online resource available for teachers to access science assessment resources to assist science teaching in the years of compulsory schooling.[8]

In 2002, the Australian Science Teachers Association played a role in raising awareness of scientific literacy to help students appreciate the relevance of science to their lives and society generally. This involved developing partnerships between schools, communities, and local industries to encourage understanding, as well as the importance of studying science in school. In 2005, the Schools, Community, and Industry Partnerships in Science Project supported 24 science-based projects across most states and territories. The goal of this project is to promote scientific literacy through local community involvement in schools projects.[9]

Evidence from international surveys indicates that Australian students perform comparatively well in mathematics and science, with some indications that they perform a little less well in the area of physical systems than in other aspects of science. There are indications from these studies that Australian secondary school students are not as interested in learning science or as favorably disposed to scientific inquiry or its application to environmental issues as their counterparts in other countries. This limited interest may be reflected in participation in science studies. From 1991 to 2006, there has been a steady decline in the percentage of senior secondary students participating in biology (from 36 to 25%), chemistry (23 to 18%), and physics (21 to 15%) that has been only partly compensated by the emergence of participation in other science studies. There also has been a decline in participation in advanced levels of mathematics. This means that the pool from which students of science-related studies are drawn has diminished, with potential consequences for participation in university studies in science, engineering, mathematics, and technology and beyond school.

The Mathematics Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Mathematics Through Eighth Grade

The National Statements of Learning for Mathematics[10] describe what young Australians should have the opportunity to learn and develop in the early school years. The Statements of Learning and their professional elaborations draw upon the following goals, which are a synthesis of those from mathematics curriculum across Australia. They are intended to provide students with the opportunity to develop the following skills.

Knowledge and understanding of concepts, ideas, and facility with mathematical skills and processes across key areas of mathematics:

- Mental and written computation and numerical reasoning
- Function and pattern, generalization, and logical and algebraic reasoning
- The identification and measurement of attributes or characteristics of shapes, objects, data, and chance events
- Geometric reasoning and the visualization, representation, location, and transformation of shapes and objects in space.

Capacity and disposition in deploying mathematical knowledge, understanding, skills, and processes in a range of situations:

- Using and building on prior knowledge, generalizing to other contexts, making conjectures, and incorporating new information into existing structures
- Posing and solving problems, mathematical modeling, developing proofs, and conducting investigations
- Thinking creatively, generating alternatives when solving problems, and working individually and cooperatively
- Reflecting upon and discussing mathematical ideas, problems and processes, and formulating and testing their own solutions and having these tested by others
- Evaluating representations of mathematical information and challenging mathematical ideas by considering purpose and point of view.

Capacity to communicate effectively:

- Using informal and formal mathematical language to logically and clearly convey mathematical understanding, thinking, and reasoning in oral, electronic, and written media
- Representing mathematical ideas and reasoning in different ways that reflect conceptual understanding for various audiences and purposes
- The selection and effective use of a range of mathematical strategies, models, information and communication technologies, and related critical literacies.

Enjoyment of mathematics and confidence in the use of mathematics in everyday situations through appreciating the following:

- Its relevance as part of their personal and working lives
- Its nature as a dynamic, diverse, and complex domain with interwoven and interconnected concepts
- The nature of mathematical thinking and its historical and cultural roles.

The National Statements of Learning are arranged by year level and structured around five mathematical strands that are considered essential and common.

Working mathematically involves mathematical inquiry and its practical and theoretical application. Key aspects of working mathematically, individually, and with others are formulation, solution, interpretation, and communication.

Numbers involves the study of representation and models for numbers, counting, magnitude, order, and computation. This includes number systems, their properties, and exact or approximate calculation with numbers that are carried out mentally and by hand using written algorithms and technology.

Algebra, functions, and pattern involve the study of general relationships between objects and their representation by the formal or informal use of variables.

Measurement, chance, and data involve the study of unit, measurement and error, events and likelihood, and data and inference.

Space involves the study of shape and location.

The Science Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Science Through Eighth Grade

As with mathematics, the ministerial council identified science as a key learning area for Australian students and requested that Statements of Learning for Science[11] be developed. The statements are organized by year level and are structured around three broadly defined aspects of the science curriculum that are considered essential and common—science as a human endeavor, science as a way to know, and science as body of knowledge. They articulate a common set of learning opportunities that Australian students should have relating to knowledge, skills, understandings, and capacities. The Statements of Learning and their professional elaborations draw upon the following aims which are a synthesis of those from science curricula across Australia. They are intended to provide students with the opportunity to do the following.

- Develop scientific literacy so students can make informed and ethical decisions about applications of science to local and global issues and their own health and well being
- Use the processes of working scientifically, reflection, and analysis to investigate and test ideas, refine knowledge, and pose new questions
- Develop understandings of the importance of critical thinking, objectivity, logical reasoning, and ethical practices in science research
- Experience the excitement and creativity of scientific enterprise, recognizing that scientific questioning and curiosity seeks to make sense of phenomena
- Use appropriate ways of representing and communicating science understandings and viewpoints to audiences for a range of different purposes and thereby contribute to and engage in public debate and decision-making

- Recognize the developing and changing nature of science and scientific knowledge as a human endeavor with its own histories and ways of contributing to society
- Learn about current Australian research and achievements and their contribution to the community, realizing that science offers rewarding career pathways and opportunities for lifelong learning
- Acknowledge that aspects of scientific thinking are carried out by all people in different cultural, environmental, and economic contexts and that this influences how scientific knowledge develops and is used within those cultures
- Develop an understanding of science concepts and use these to explain and predict events of the physical and biological worlds.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Time

The number of hours per week that are allocated to mathematics and science is a school-level decision. The exception is New South Wales where a minimum of 400 hours of science teaching is required before the completion of Year 12.

Data from TIMSS 2002 indicates that Australian grade 4 students spent an average of 5 percent of their instructional time on learning science,[12] in life science (40%), earth science (30%), and physical science (20%).[13] The corresponding figure for mathematics in TIMSS 2002 was 20 percent of the teaching week, mostly centered on numbers (40%), patterns and relationships (18%), measurement (17%), geometry (12%), and data (11%). Angus, Olney, and Ainley[14] conducted a detailed study in 2007 of a national sample of 160 primary schools and found that primary school science occupied 45 minutes per week (or 3% of an average week), and mathematics occupied 18 percent of the week. More than one quarter of the teachers considered that the time allocated to science was not sufficient.

According to data for grade 8 from TIMSS 2002, an average of 208 minutes per week was allocated to mathematics teaching and an average of 192 minutes per week was allocated to science teaching. Of the mathematics time, 23 percent was focused on algebra, 18 percent on geometry, 16 percent on measurement, and 14 percent on data. The science time was divided between life sciences (26%), chemistry (23%), physics (21%), earth science (16%), and environmental science (11%). The instructional time for science in grade 8 varied across jurisdictions from 165 minutes per week in Victoria to 216 minutes per week in western Australia. In mathematics, the range was much narrower, from 197 minutes per week in Tasmania to 233 minutes per week in western Australia.[15]

Instructional Materials, Equipment, and Laboratories

Each school has the responsibility of determining which mathematics and science textbooks are used for teachers' and students' resources. However, it is important that schools ensure that the textbooks cover the key learning areas and the ministerial council's statement of learning. The report *Teaching Science in Australia: Results from* *the TIMSS 1999 Video Study* noted that according to the responses by teachers on the teacher questionnaire, it was generally found that, "Australian teachers and students were relatively very well provided with science laboratories, microscopes and reference materials. Teachers identified a shortage of computers and software." [16]

Grade at Which Specialist Teachers for Mathematics and Science Are Introduced

Students in Australian primary schools usually have one teacher for most subjects. Unlike primary schools, students in secondary schools generally have a different teacher for separate subject areas.

Use of Technology

The use of calculators in mathematics is widespread in Australian schools. The Australian national report on TIMSS 2002 mathematics[17] found that in grade 4, 94 percent of teachers allowed the use of calculators in the classroom, with its main use being to check answers, solve complex problems, and explore number concepts. Similarly, in Year 8, 96 percent of Australian teachers allowed the use of calculators, mostly for routine computations, checking answers, and solving complex problems. It also was found that 76 percent of grade 4 students had access to a computer in the classroom, however, it only was used moderately in mathematics to practice skills and procedures. In Year 8, with mathematics being taught in general classrooms, only 54 percent of Australian teachers had access to a computer and only 1 percent of classrooms had use of computers for more than half of the mathematics lessons.[18]

Teachers and Teacher Education

Education and Training for Fourth and Eighth Grade Mathematics and Science Teachers

Teacher training occurs in universities, but states are responsible for determining acceptable teacher qualifications. There are two general forms of initial teacher education.

- *A post-graduate qualification in education following successful completion of another bachelor's degree*: Most secondary science and mathematics teachers follow this route, accounting for 34 percent of all teacher education courses completed. These courses usually are 1 year, however, 2-year programs also have been developed. In total, 4 years of higher education is the average length of initial training for secondary teachers.
- *A concurrent program combining liberal arts studies and education following completion of secondary school or transfer from an incomplete tertiary course*: Most undergraduate teacher education programs for students intending to be primary teachers are either 4-year education degrees or double degree programs taken concurrently. However, there is limited opportunity to develop specialist knowledge in mathematics or science. Primary teachers who completed a 3-year teaching diploma can upgrade their qualifications by undertaking specialist 1-year diplomas or a general fourth year resulting in the award of a degree.

Nationally, the overall supply of teachers has been adequate. However, recruiting difficulties exist for specialized subjects in secondary school. These subjects include physics, chemistry, and mathematics.[19] According to a national survey of staff in Australian schools, half of the mathematics teachers in lower secondary schools (grades 7 or 8 to 10) have completed at least 3 years of tertiary education in mathematics (and three quarters have completed at least 1 year of tertiary study in mathematics), and 60 percent have completed teaching methodology training in mathematics.[20] Two thirds have greater than 5 years teaching experience in mathematics. It is harder to estimate the percentages of teachers of science in the lower secondary school with 3 years of tertiary study in science, but the figure appears to be similar to those for mathematics.

Teacher Professional Development in Mathematics, Science, and Technology

Australian education authorities recognize that professional development is imperative to maintain the vitality of the teaching profession. The national survey of staff in Australian schools indicted that, on average, teachers spent 9 to 10 days engaged in professional learning over the previous 12 months, and this did not differ significantly between primary and secondary school teachers or across regions.[21] An earlier study indicated that this was divided between 2 to 5 days of professional development within school hours and more than 4 days in out-of-school professional development activities.[22] The national survey of staff in Australian schools indicted that 58 percent of mathematics teachers in lower secondary school had engaged in professional learning activities in that area in the past 12 months.[23]

Examinations and Assessments

National or Regional Examinations

The National Assessment Program for Australia was established by federal and state education authorities over a 5 year period. It involves a full-cohort assessment of students in grades 3, 5, 7, and 9 in literacy and numeracy; a program of sample assessments at grades 6 and 10 in science, civics and citizenship, and information and communication technology conducted every 3 years; and participation in TIMSS and PISA. Until 2007, the full cohort assessments in literacy and numeracy were based on state tests with benchmark or minimum competency standards. Beginning in 2008, common national tests and common procedures were used. The assessment instruments used in these testing programs incorporate a range of items including multiple choice and constructed response. The purposes of these programs are to report information about student achievement based on a common test to parents, teachers, and schools and to monitor the overall performance of the education system. These testing programs reflect the increased emphasis on evaluation for accountability purposes.

At the end of secondary school in grade 12, all states conduct formal assessments (typically 2 hours in duration) of student performance in subjects. The examinations are conducted by panels of experts in each of the subjects under the authority of the state curriculum and assessment authorities. The purpose of these assessments is to certify student achievement at the end of school. They also provide the basis for selection of courses in higher education. In most states, the assessments are based on a combination of curriculum-specific formal examinations conducted by a state authority and school-based assessments of student performance on specified tasks or assignments. In Queensland and the Australian Capital Territory, there are no external examinations but internal school assessments are adjusted against students' scores on an aptitude test to achieve comparability across schools. These end-of-school examinations are high stakes in the sense that the results are used as the basis for selection into university courses. In New South Wales all students in grade 10 are tested in English, mathematics, and science through reference tests that are used to moderate school assessments in the School Certificate Program. Other states do not have formal examinations other than at grade 12.

Other Tests

In addition to participating in the national assessment program, state and territory authorities conduct assessments in their jurisdictions in areas not encompassed by the national program. Examples of these are the Essential Secondary Science Assessment in New South Wales for grades 7 though 10 and the Western Australian Monitoring Standards in Education program that tests samples of students at several grades throughout the span of schooling in all eight key learning areas (including mathematics and science). Some education systems have introduced assessments at the point of entry into primary school in order to provide information teachers can use to develop appropriate education programs for individual students.

School-based assessment is the most common mode of assessment at the primary and lower secondary levels of schooling. In primary schools, assessment is mainly informal, making use of checklists, observations, projects, and portfolios. In the lower secondary grades, there is use of teacher-made tests, including multiple-choice, short-response, and extended-answer formats. Projects, laboratory assignments, and seminar presentations also form part of the assessment process. These local assessments sometimes make use of assessment tools, including online assessment tools, developed by nonprofits (such as the Australian Council for Educational Research, the Curriculum Corporation, and the Learning Federation) and commercial suppliers outside of the education systems. Over the past 10 years, there has been greater use of a wider range of assessment instruments (rather than just traditional written tests) and continuous assessment rather than end-of-term tests. At the local level, assessment is used for a variety of purposes: evaluating student progress, reporting to students and parents, evaluating programs, and (at the lower secondary level) providing guidance about further courses of study.

Monitoring Individual Student Progress

A major development over the past decade has been the use of progress maps to report student progress in terms of a developmental continuum in the subject area, which gives an indication of what a student could be expected to do, as well as an indication of one or more references such as the average for the school or the state.[24] In addition, norm-referenced reporting based on letter grades (A to E) is still used. A report to the federal government argued for greater uniformity and consistency in the way student performance is reported.[25]

Grade Promotion and Retention Policies

Australian primary schools follow regular grade promotion practices, with students normally progressing each year from one grade to the next. In secondary schools, special circumstances may lead to retention at the end of grade 10.

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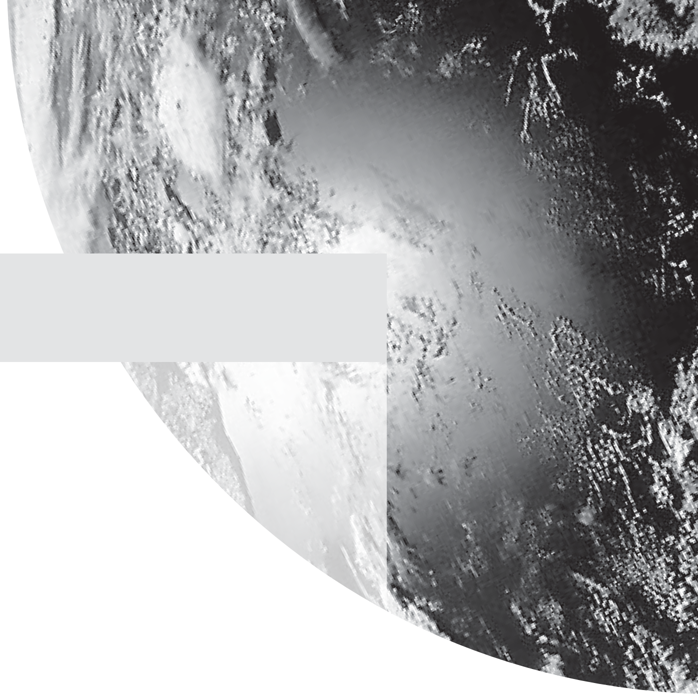

Austria

Ministry for Education, Arts, and Culture
and the National Research Center Austria

Introduction

Overview of Education System

Austria has nine federal provinces, referred to as *Bundesländer* or *Länder.* The responsibility for legislation and its implementation is divided between the federation (*Bund*) and the *Länder.* Legislation is executed by the parliament and administrative offices of the *Länder,* while the federation has responsibility for the education system, including the oversight of all areas of school management, the organization of school instruction in public and private schools, and legal foundations for the remuneration and retirement of education staff.

The Austrian school system is hierarchically organized and highly centralized. Since March 2007, the Ministry for Education, Arts, and Culture has been responsible for primary, secondary, and nonuniversity tertiary education.[1] The Ministry for Science and Research is responsible for universities and a university-level study program with a vocational and technical orientation (*Fachhochschulen*). The Ministry of Economic Affairs and Labor has responsibility for apprenticeship training within companies.

The *Länder* are mainly responsible for the provision of public-sector compulsory education. They support local communities in establishing and maintaining these schools via school construction funds, which they themselves administer. Provincial school inspectors in each of the nine *Länder* are responsible for inspections, and are assisted by district school inspectors for compulsory schools and subject inspectors for the intermediate and upper secondary levels. Furthermore, the *Länder* have sole responsibility for *crèches* (day nurseries).

Based on proposals drafted by curricular task forces, the Ministry for Education, Arts, and Culture establishes a curricular framework through a consultation process, which includes district and provincial educational bodies and organizations of teacher representatives. Schools enjoy some autonomy in budgetary management and, to some extent, are free to adapt the curriculum to local needs. Attendance at state schools is tuition free.

Preprimary education, for children ages 0 to 6, includes baby or toddler *crèches* (ages 0–3). Between the ages of 3 and 6, children may attend a nursery school. Preprimary education is, however, not compulsory. The federation does not govern this section of education, rather each *Bundesland* has its own legislation.

Education is compulsory for a total of 9 years and begins with **primary education**, *Grundschule* or *Volksschule,* for ages 6 to 10. There are two levels of *Grundschule.* Level I includes preschool and grades 1–2, and level II includes grades 3–4. School-age students who are not mature enough to go to school have to attend preschool for a year before they begin with primary school. In addition to the primary grades offered in *Grundschule, Volksschule* includes upper primary grades 5–8, although the upper primary grades are offered at only very few locations.

The next stage is **lower secondary education,** for children ages 10 to 14, who attend either a secondary general school (*Hauptschule*), a lower level secondary academic school (*Allgemein bildende höhere Schule*), or an upper primary level (*Volksschule),* although the latter is very rare.

Beginning at age 14, students may attend **prevocational school** *(Polytechnische Schule*), which lasts only a year or any other upper secondary school. Prevocational schools emphasize vocational orientation and training in specialized areas in a wide range of fields, such as technical occupations, clerical occupations, the service industry, and the tourism industry.

Upper secondary education, for ages 14 to 18 or 19, lasts 4 or 5 years. There are several different types of upper secondary schools including general secondary academic school (which is the continuation of lower level secondary academic school), technical school, and vocational school. The goal of these types of schools is graduation (*Reifeprüfung/Matura*), which allows access to higher education.

Postsecondary education and higher education begins at ages 18 or 19. Many institutions, including public and private universities, offer tertiary education programs (ISCED levels 5 and 6) in a range of subjects and specialties.

Language and Population

German is the official language and language of instruction in Austria. In regions with a linguistic minority, there are bilingual institutions that divide instruction between German and Slovenian, Hungarian, or Croatian. The school law for minorities regulates this separately for each *Bundesland*. Furthermore, there are some, mostly private schools, which teach in languages other than German in particular subjects (e.g., mathematics or science lessons in English).

Emphasis on Mathematics and Science

In recent years, a wide and diversified range of initiatives, programs, activities, and projects in the field of mathematics and science and technology education have been established by different stakeholders such as teachers, ministries, universities, and a variety of partners from business and society.

Innovations in Mathematics, Science, and Technology Teaching[2] is a cooperative project of the Austrian Federal Ministry for Education, Arts, and Culture, together with universities and colleges, universities of education (*Pädagogische Hochschulen*), and schools, and is an exemplary, broad, and well-implemented project of national importance.[3] Its goal is to establish a sustainable support system to develop the quality of teaching and learning in mathematics and science and technology, as well as informatics and other related subjects taught in Austrian schools and colleges. The project takes place at the primary and secondary levels and has led to some structural innovations in the Austrian education system. Furthermore, this has led to the implementation of six Austrian Educational Competence Centers located at different Austrian universities, which develop and carry out a university course for subject-related educational management for teachers.[4,5]

Overarching Policies Related to Education and the Curriculum for Mathematics and Science

The curriculum for mathematics in primary schools was revised in 2003, and expert teams have adapted the curriculum according to requirements and actual standards. The science curriculum also has undergone revisions since 2006, which are still in progress.

In lower secondary schools, the current curriculum was introduced in 2000 but only minor changes were introduced to the curricular topics. The changes were mainly concerned with the separation of the curriculum into core and extension domains. Two thirds of instructional time must be devoted to the core domains, defined in the curriculum, while one third of instructional time can be chosen from the extension domains not defined in the curriculum.

The Mathematics Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Mathematics Through Eighth Grade

The curriculum for **primary education**, grades 1–4, consists of different parts: general educational targets, including the tasks of the school; general rules about the organization of grades in primary school; planning instruction and use of teaching methods in the curriculum; general didactic principles; subject tables; educational and instructional tasks; and the content of the curriculum for different subjects.

The content of the curriculum for grades 1–4 is divided into four mathematical domains: structure of the natural numbers, arithmetic operations, quantity, and geometry. All four domains are part of the curriculum for each grade. Whereas the learning targets for grades 1 and 2 are combined, those for grades 3 and 4 are separated. In grade 4, the topic, fractional numbers is added to the second domain, arithmetic operations.

In the first domain, *structure of the natural numbers*, students should develop basic abilities in mathematics and be able to understand numbers. In grades 1–2, students use numbers up to 100. In grades 3–4, students' understanding of numbers will be expanded and deepened, and the number spectrum will reach up to 100,000.

The *arithmetic operations* domain ranges from learning the concepts underlying the operations to carrying out all four arithmetic operations (addition, subtraction, division, and multiplication), appropriately employing these operations, and using them to solve real-life problems. In grades 3–4, the use of arithmetic operations intensifies and the number spectrum in which the operations take place becomes progressively larger. Additionally, in grade 4, students learn about fractional numbers that have 2, 4, or 8 as a denominator.

Quantity, the third domain, develops understanding about comparing, and formulating relationships with different units of measurement such as length, time, and weight and applying quantities in different situations. In grades 1–2, students develop a concept of quantity and learn and apply the different units of measurement. The focus in grades 3–4 is on estimation, as well as measuring, comparing, and transforming units of measurement.

The main targets in *geometry* for grades 1–2 are observing, ordering, and structuring spatial relationships and shapes; enhancing the ability to orientate; using plotters, and making quantitative links to the work. Students investigate and describe simple geometric figures. In grades 3–4, the focus is on identification and classification of geometric figures, measuring objects, and using plotters. Furthermore, students learn how to calculate circumference, as well as perimeter and area, in particular for rectangles and squares.

In **lower secondary education**, grades 5–8, the curriculum for the secondary general school and the lower level of secondary academic school are similar. One slight difference concerns the grouping of students during lessons. In the general secondary schools, students are grouped into three achievement levels according to their abilities in the subjects German, mathematics, and foreign language (usually English). Students in the highest achievement level must meet the same expectations as students in the lower grades of the academic secondary schools. In those subjects that all students must attend, the curriculum differentiates between core and extension domains, as described previously.

The core domain content for grades 5–8 includes the following subdomains: working with numbers and quantity, variables, figures and solids, and models and statistics. These are described below.

Working with numbers and quantity in grade 5 enhances the ability to use natural numbers, and familiarizes students with decimals and fractions and the rules for the order of arithmetic operations. Students also gain confidence about doing mental arithmetic and using electronic media. In grade 6, this subdomain is mainly devoted to decimal and fractional arithmetic. Percentages and the use of dimensions are also important themes. In grade 7, students illustrate numbers relative to zero and learn about a system of coordinates, as well as greater than or less than. In grade 8, students study how arithmetical situations cannot always be solved with rational numbers.

Working with variables in grades 5–6 focuses on formulas and linear equations, as well as the ability to describe general situations with variables. In grade 7, students learn to transform formulas and justify the transformations with rules. They solve linear equations with one unknown term. The aim of the curriculum in grade 8 is to reinforce the work with variables, formulas, and equations and to teach students how to display their work graphically and solve linear equations with two variables.

When *working with figures and solids*, students in grade 5 learn to recognize and describe geometric figures and solids, as well as their properties. Additionally, they have to draw and construct rectangles and circles, calculate the perimeters, area, volume, and surface area of cuboids or solids and work with angles and symmetric figures. In grade 6, work with geometric figures is intensified and extended to triangles and squares, and students learn about the degrees of angles, and angle symmetry and the volume of prisms. The Pythagorean theorem, the solving of reversal tasks, and the increasing and scaling down of figures are included in the curriculum in grade 7. In grade 8, students learn the justification of the Pythagorean theorem, calculate the circumference and area of circles, and use formulas to calculate surfaces and volumes.

Working with models and statistics in grade 5 includes using tables and graphical displays to convey data, comparing models with real-life situations, and understanding the significance of models. In grade 6, this subdomain entails calculating relative frequencies and learning characteristics of direct and indirect proportions. In grade 7, students learn about increasing and decreasing processes, such as interest loans. This is continued in grade 8, in addition to the investigation and display of functional dependencies and the use of statistical key data to display data.

The Science Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Science Through Eighth Grade

Science instruction in **primary school** is divided into the following learning areas: community, nature, space, time, economics, and technology. All six of these learning areas are part of the subject matter in each of the four primary grades. In the curriculum, the subject matter is collectively described for grades 1–2. For grades 3–4, however, it is described separately.

The learning area *community* is about the social experiences, social life, and social actions of the children. The topics in grades 1–2 include the school class as a new community; living together in different communities as families, friends, and neighbors; and the knowledge of oneself and others. In grade 3, students learn to understand these communities through active participation and familiarize themselves with public facilities, such as police stations. In grade 4, these topics are intensified.

Nature focuses on understanding the environment, as well as knowledge of the human body. The relevant texts refer to life processes and biological systems, the variety of shapes in nature, responsible attitudes toward nature, and the human body and health, including human sexuality. In grades 1–2, the themes are introduced with simple examples. In grade 3, these themes are enhanced, and in grade 4, the emphasis is on a further understanding and application.

The learning area *space* in grades 1–2 orients students to their immediate surroundings. Furthermore, they should recognize and be able to name simple geographical conditions. In grade 3, students learn about orientation facilities and use them to do exercises. In doing so, different types of landscapes and forms of housing are examined, described, and portrayed in diagrams. In grade 4, they learn about the geography of their own

Bundesland, as well as other regions within and beyond Austria and gain a deeper insight by using maps.

Time includes orientation in the time dimension, understanding that time lapses are observable, and how time is divided and measured. In grades 1–2, students acquire an age-appropriate meaning of history, which classifies their experiences in a time frame. In grade 3, they identify changes to the immediate surroundings over the course of time, such as changes in people and objects. In grade 4, they learn about changes in time in the broader environment and interpret them. Through specific pictures of history and culture, especially from their own *Bundesland*, students receive their first historical views.

The learning area *economics* concerns economics and its connections to the real world through concrete examples. In grades 1–2, students learn about support, work, and income. In grade 3, this includes the family as an economical community. In grade 4, these subject areas are enhanced, and students also learn about economic systems, work, profession, and recreation, making real-world connections.

The learning area *technology* is about technical facts in the environment, natural forces and their effects, and substances and their transformation. In the first two grades, the subtopic technical facts in the students' environment relates to mechanical objects such as tools, wheels, handles, and switches. In grade 3, this knowledge is extended to the indirect environment, and in grade 4, it is further enhanced.

Students also learn about the handling of objects and specific operational methods through examining, measuring, and experimenting with objects. In the first two grades, students are introduced to these methods, and in grades 3–4, this knowledge is extended and enhanced. Furthermore, using technical equipment responsibly is covered at all grade levels.

The science curriculum in **secondary general schools** and the **lower level of secondary academic schools** is the same for grades 5–8. Biology, geography, physics, and chemistry are described separately in the curriculum and each constitutes its own subject.

Biology mainly covers human beings and health, animals and plants, and ecology and the environment. The topic *human beings and health* provides an overview of the structure and function of the human body, deeper understanding of sexuality and movement, and the effects of micro-organisms and the forest's ecosystem on human health. *Animals and plants* covers structure and function of local animals and plants, specifically vertebrates, spermatophyte, and pets (grade 5); invertebrates, spermatophyte, cryptogams, fungi, micro-organisms, and cells (grade 6); useful plants and production animals (grade 7); organisms and their roles in urban ecology and the ecology of other areas (grade 8). *Ecology and the environment* includes basic ecological terms; positive and negative outcomes of human effects; environmental problems and protection and conservation, using examples from vertebrates and forest ecosystem (grade 5); forest ecosystem and national waters (grade 6); land ecosystems and agricultural ecosystems (grade 7); and urban ecology and the ecosystem of other areas (grade 8).

Geography and economics in grades 5–6 covers basic skills and comprehension through simple examples and also teaches students about the diversity of human life and economy on Earth. Using globes and maps, students learn about the life and economy of people in different areas, use of resources and energy, economic systems and climatic conditions, living in urban communities, goods production in industrial and commercial enterprises, fields of services, and the Earth as a living and economic area. In grades 7–8, these are extended and enhanced.

Physics, in grades 6–8, gives students a general understanding that should be applied to concrete circumstances through examples. The curriculum is built on single modules, which can be used in a different chronological orders, as well as for different emphasis.

The modules for grades 6–7 are described as follows: *physics determines our life* includes physical thinking and the difference between physical and nonphysical thinking; *the world in which we are moving* describes procedures that hinder or support movement, including weight and friction; *all solids consist of particles* explains the particle model and its effects on solid properties such as the structure of solids and heat phenomena; the development and broadening of sound; and swimming, floating, and the falling of solids in water; *the dream of flying* explores procedures when flying; *our life in a warming bath* describes thermal procedures in the living and inanimate world, heat conduction, heat flow, and heat radiation or understanding of global or local weather; *electrical phenomena are omnipresent* addresses electrical procedures in everyday life and nature; and *electrical engineering enables quite a lot* describes the construction and effects of electrical equipment, the importance of safety, and economy measures.

In grade 8, the issues are also organized into modules and can be described as follows: *electricity determines our life* looks at technical production and consumption of electrical energy; *the world of the visible* explores formation and dispersion of light; *curved pathways on Earth and in space* examines the effects of forces and the movement of objects; and *the radioactive reaction of material* addresses procedures in the atomic nucleus.

Chemistry is taught in grade 8 and includes the following subjects: classification and characteristics of materials, the principles of material construction (e.g., particle and atom model), basic pattern of chemical reaction (e.g., attributes and reaction of acids), sources of raw material and their responsible use (e.g., water and earth as raw materials), and biochemistry and health education (e.g., the raw material of food).

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Time

The total amount of instructional time in a typical week, as prescribed by the curriculum in the fourth grade, is 21 hours. Of the total instructional time, 18 percent is intended for mathematics instruction and 15 percent for science instruction.

In grade 8, the total amount of instructional time prescribed by the curriculum is 26 hours and 40 minutes, 12 percent of which is intended for mathematics instruction and 16 percent for science instruction. Since lower secondary education consists of two different school types, the number of mathematics and science lessons during grades 5–8 varies slightly. The data given here is an average.

Instructional Materials, Equipment, and Laboratories

The mathematics curriculum does not prescribe materials for grades 4 or 8, rather the teachers decide which materials and methods to use. However, the curriculum specifies teachers should use a variety of methods. Furthermore, there is a list of approved books, provided by the ministry, from which teachers can choose a textbook for their subject.

Grade at Which Specialist Teachers for Mathematics and Science Are Introduced

In grade 5, students have specialist teachers for mathematics and science for the first time. Specifically for science, there are specialist teachers for biology and environmental education, physics, and chemistry.

Use of Technology

In the curriculum for primary education (grades 1–4), there is only a general recommendation that computers be used for learning and creative work for mathematics and science. The use of calculators is introduced in the fifth grade.

However, the curriculum for lower secondary education (grades 5–8) requires the integration of computers into mathematics in all grades. The use of computers, although not prescribed for science subjects, is generally desired in all subjects.

Homework Policies

The curriculum for primary education contains only a general statement about the time for individual learning, including homework and the amount of homework. However, it does not state that the teacher has to give homework.

The same is true for lower secondary education. The curriculum does not contain a statement about assigning mathematics or science homework. However, regular homework in mathematics is usually given, while homework in science is rare and not frequently assigned.

Teachers and Teacher Education

Education and Training for Fourth and Eighth Grade Mathematics and Science Teachers

There are two main streams of education for teachers in grades 1–8. Teachers for *Grundschule* and *Hauptschule* are educated at special universities of education (*Pädagogische Hochschulen*) and receive a Bachelor of Education that takes 3 years to complete. Teachers for *Allgemein bildende höhere Schulen* (secondary academic schools) are educated at general universities leading to a master's degree. Prior to the 2007–2008 winter term, the training for primary school teachers and secondary general school teachers was the responsibility of colleges for teacher training. Admission to all kinds of teacher education programs requires a general higher education entrance qualification obtained through the upper secondary school leaving examination.

In addition to completing coursework, teachers for *Grundschule* and *Hauptschule* visit schools to observe and practice teaching under the supervision of experienced teachers and receive complementary training at seminars. Upon successful completion of a bachelor's thesis and the final state examination, teachers obtain a qualification certificate.

The primary school teacher is a generalist who is able to teach all the disciplines of the primary school curriculum. There are no specific mathematics and science teachers in primary schools, since teachers in primary schools are responsible for instruction in all subjects.

Teachers for secondary general schools, however, train in two subjects. Students have to choose a first subject (German, English, or mathematics) and a second subject out of the other compulsory subjects, including physics or chemistry, biology, and geography, for science.

Teachers who are training to teach at the *Allgemein bildende höhere Schulen* complete coursework in two disciplines, in addition to other educational courses. Science-related subjects include biology, chemistry, geometry, geography, and computer science. Teachers also complete a school practicum that takes 4 weeks of preparation and 8 weeks of experience in the two selected subjects.

Having obtained a master's degree, however, does not fully qualify the graduate for definite employment as a teacher. University graduates must take an additional year in the subjects they are teaching at school, with a reduced teaching load supervised by a specially trained teacher.

Teacher Professional Development in Mathematics, Science, and Technology

In Austria, there are special departments *(Pädagogische Institute*) connected to the ministry that provide a wide variety of opportunities for continuing professional development for teachers. Beginning in the 2007–2008 school year, these were integrated into the universities of education. Since 2001, teachers of primary schools and secondary general schools must attend 15 hours per year of professional development activities. There is no compulsory professional development for teachers of academic secondary schools.

Professional development addresses topics that are not covered or only partially covered in education studies and range from short 1-day courses to courses over several semesters. Some focal points are subject-specific workshops, information technologies, school development, and internationalization.

Examinations and Assessments

National or Regional Examinations

In Austria, there is no formal, external testing during compulsory education. Teacher-generated assessment is based on classroom participation and oral, written, practical, and graphical work. Primary school students have to take written examinations (school tests) in German and mathematics in grade 4.

Other Tests

In 2003, the Federal Ministry for Education, Science, and Culture assigned a group of experts to develop, implement, and pilot a system of national educational standards,[6] which should guarantee the quality of school education, the international comparability of school-leaving certificates, and the permanence of the Austrian education system. Austrian national standards are based on a model describing different areas of competence.

Following the evaluation of pilot tests, national standards will be implemented in 2008 at levels 4 (primary education) and 8 (secondary education). The first examinations will be in 2009 in the form of a baseline test. These examinations will demonstrate the degree of success to which Austrian schools have imparted the core competencies stated in the educational standards. They will provide results regarding the efficiency of the education system (system monitoring). However, they will not be used as a basis for grading students. Teachers will receive feedback comparing the competency of their classes with national results. The aim of implementing educational standards is to introduce a data-based process for quality development in schools, drawing attention to outcome-based education.

Monitoring Individual Student Progress

Performance assessments are conducted by teachers throughout the school year and entail active participation of students in class work; oral assessment; written assessment, including class assignments, tests, and dictations; practical assessment; and graphic assessment.

Marks range from 1 to 5, 1 being the best. Both compulsory and optional subjects are graded. School reports contain a summary of student achievement. Schools issue reports at the end of the first semester, at the end of the year, and in certificates after successful completion of a particular type of school. The annual report considers student achievements during the entire year, but particular weight is given to the most recent assessment.

Grade Promotion and Retention Policies

Generally, students are entitled to enter the next year if they have been assessed in all compulsory subjects and never rated as insufficient. Technically, the law allows students to progress to the next year with one insufficient rating, if the subject will be taught in the next year and the performance in the other subjects is good. Students whose performance is deemed insufficient in no more than two compulsory subjects also may take a test in these subjects at the beginning of the following school year. If they fail, they have to repeat the year in question.[7]

Marks are not given in the preprimary class. The first 2 years of primary education constitute a single cycle and therefore students are entitled to enter the second year regardless of their assessment in the annual report. Primary school students also are entitled to proceed to the next level regardless of their grade in the compulsory subjects of music, drawing, technical and textiles, and physical education.

In year 4, students complete between four and six assignments in both German and mathematics. Together with parents, teachers establish (in a class or school forum) whether the use of a description of achievement will accompany the marks in the first and second years.

Suggested Readings

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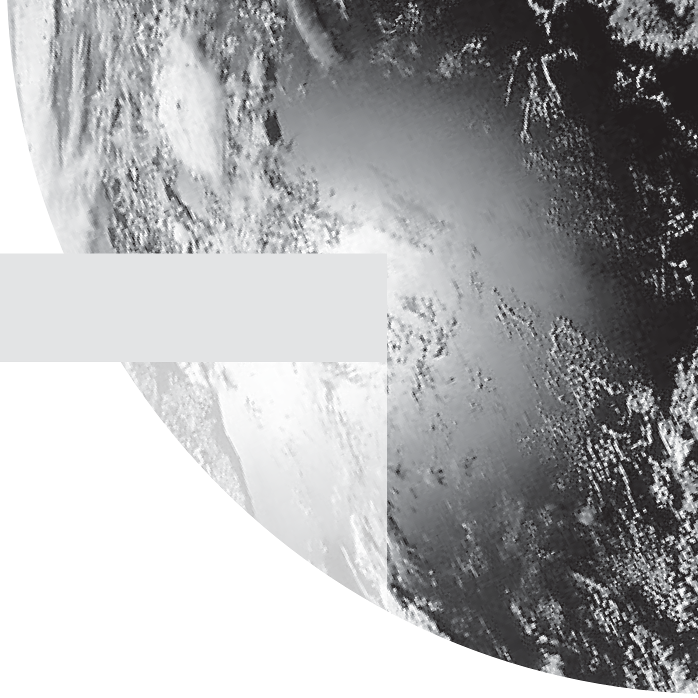

Bahrain

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Introduction

Overview of Education System

Article 7 of the National Bahrain Constitution[2] legislates that education and cultural services are guaranteed to all citizens, and "education is free of charge in basic and secondary public schools." In Bahrain, the first 9 years of basic education are compulsory for children ages 6–14 in either public or private schools, as specified and provided in Article 6 of the Education Law.[3]

Government public schools are run by the Ministry of Education. Schools are responsible for their own daily administrative and academic affairs under the umbrella of the Ministry of Education. The fundamental education system has been applied in a number of schools since the 1990–1991 school year. The philosophy behind this system is to give the school some autonomy.

The Bahrain Ministry of Education[4] is responsible for management of all levels of the education system. Plans to combat illiteracy are laid down by law. The ministry is the official body responsible for implementing the kingdom's policies in education. The government and private sector share the management of the educational institutions as follows.

- **Nurseries** (age 3) are run by the private sector, under the supervision of the Ministry of Social Development.
- **Preschool education** (ages 3–5) includes kindergartens run by the private sector, under the supervision of the Ministry of Education.
- **Primary education** (ages 6–17) includes three school stages. The first cycle, grades 1–3; second cycle, grades 4–6; and the third cycle, grades 7–9 (intermediate stage).

The private educational institutions[5] are composed of different types of schools, such as nurseries, kindergartens and private schools, colleges, and educational centers. Private schools differ according to their education systems and the policies and educational bodies they follow. These bodies have a clear role in determining the course of education in their private educational institutions. Private schools in Bahrain are divided into three types: national private schools, foreign private schools, and foreign community schools. Each school has its own curriculum, teaching plans, and textbooks approved by the Ministry of Education. Private schools are obligated to use the curriculum and textbooks that the ministry approves concerning the Arabic language for Arab students, Islamic studies for Muslim students, and Bahrain history and geography for all students. Presently, the total number of public schools is 205, and the number of private schools is 66.

Language and Population

The official language in Bahrain is Arabic, but English is widely spoken and widely used in business. Arabic is the language of instruction in public schools. English is taught as a compulsory foreign language, and French is taught as an elective second language. The curriculum for all subjects in private schools in Bahrain is presented in English, except in French schools where French becomes the first language. Recently, the Minister of the Bureau of Affairs announced in all official papers that the population of Bahrain is estimated to be 1,046,814 (Bahraini, 529,446, and non-Bahraini, 517,368).[6,7]

Emphasis on Mathematics and Science

The High Committee of Curricula[8] is responsible for preparing the curriculum in mathematics and science. The final decisions are made after all reports from the different directorates are gathered and discussed. These include directorates in educational supervision, training, and professional development; private, planning, and projects; and curricula. In addition, mathematics and science specialists, senior teachers, and principals represent the consultant committees and their decisions. Furthermore, during the 1980s, the Arab Bureau of Education for the Gulf States[9] compiled a curriculum for both subjects, which was applied in all Gulf countries beginning in 1985. Bahrain annually reviews the curriculum according to the reports received from different directorates.[10] Additionally, since 2005, after Bahrain participated in TIMSS 2003, the TIMSS team submitted a report[11] to the High Authority of the Ministry of Education specifying some of the corrections needed in the topics in mathematics and science textbooks.

The ministry is making further efforts to develop mathematics and science for all grades by collectively buying, with Saudi Arabia and Kuwait, an advanced series of mathematics and science textbooks, in order to have up-to-date concepts in these subjects. In addition, the Ministry of Education's TIMSS team[12] is working with the Directorate of Curricular and Educational Supervision to refine the curriculum in mathematics and science by observing students in order to identify limitations in students' understanding of concepts and skills. One of the main objectives will be to concentrate on reviewing the methods used in teaching mathematics and science based on the types of questions used in TIMSS. The Bahrain TIMSS team prepared a study[13] regarding the standards of mathematics and science in Bahrain and has made suggestions as to why Bahraini student achievement was affected in TIMSS 2003.

The Gulf Arab States' Educational Research Center reconsidered the curriculum in mathematics and science as the result of new projects from other countries. These projects, Science for All, Science Education Standards, etc., showed the great efforts that were spent in developing curriculum in such subjects. In addition, the implementation of efforts from UNESCO and TIMSS proved to be helpful in the teaching of mathematics and science. These projects concentrate on preparing a student to face the universal changes in the curriculum and strengthen their abilities and self-confidence.

Overarching Policies Related to Education and the Curriculum for Mathematics and Science

The hard work and great efforts made since 2001 by educators in Bahrain have impacted the development of the mathematics curriculum. The integration of new principles has emphasized the nature of mathematics, teaching procedures, and the goals that make mathematics a tool for thinking and a language of communication in students' lives.

The Bahrain Ministry of Education, for the most part, has worked on developing the basics and principles of the science curriculum since 2001, as these are necessary for the areas of natural development, natural science, and the new methodology in science education. Fundamentally, the curriculum is adjusted to suit students' characteristics and physical growth in the three cycles of the basic education, grades 1–3 (first cycle), grades 4–6 (second cycle), and grades 7–9 (third cycle). Also, the curriculum responds to students' knowledge, skills, and values, and it emphasizes their structural knowledge, methods of searching and thinking, and scientific values and habits. Educators, therefore, are able to set general goals built upon the cognitive, psychomotor, and affective domains. The specific objectives are obtained from the set goals, and the basic competency standards are implemented for the three cycles of education.

The Mathematics Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Mathematics Through Eighth Grade

The national guidelines in Bahrain for the mathematics curriculum are built upon the following five aspects.

- **Give students a greater role in the learning process** by putting them in situations that require research, experimentation, guesswork, and the use of previous experiences. Such situations should lead them to new thoughts and experiences and the discovery of new mathematical relationships and new conclusions; therefore, making mathematics a more exciting learning experience.
- **Emphasize the functional aspects of learning mathematics** and how building mathematical knowledge should be adopted as a lifelong learning experience.
- **Stress mathematical concepts, symbols, and relationships**, considering the importance of communication, discovery of relationships, and generalizing; that is, the mathematical skills that reflect the nature and meaning of mathematics.
- **Consider learning objectives and feel the importance of new mathematical skills**, making the content a complete structure, for example, mathematical skills

for communication, discovering relationships and generalizations, number sense, and logical thinking.

- **Build interest in solving problems** that need to be interpreted and converted into algebraic and graphical or geometrical expressions, making use of their skills in solving equations and principles of geometric proof.

For the first cycle, **grades 1–3**, and second cycle, **grades 4–6**,[14] the main goals of the basic education curriculum in mathematics are specified under the following three areas.

- *Knowledge and skills*: understand the meaning of numbers and mathematical operations; know mathematical language, such as symbols, terminologies, shapes, and diagrams, etc.; develop mathematical skills and number sense; develop knowledge of mathematical operations and procedures, and demonstrate they can choose the appropriate one; collect and classify different types of data to read and represent them; and use mathematical language and symbols in real life and vice versa.
- *Methodology of thinking*: apply the steps of problem-solving procedures through analyzing, planning, implementing, and validating the results; develop abilities in using mathematical concepts and skills; and acquire appropriate thinking procedures and use them in solving problems.
- *Affective (tendencies, values, and attitude)*: maintain a positive personality for the working society (self confidence, logical thinking, objectivity in judgment, respect of others, accuracy, organizing, perseverance, and correct usage of time); develop self-esteem and accept success and failure; be motivated and develop a love of mathematics; and acquire an appreciation of the need to protect the environment through quantitative examination of some environmental issues (pollution, limitation of consumption, etc).

The main goals for the third cycle, **grades 7–9**, of basic education in mathematics are specified under the following three areas.

- *Knowledge and Skills*: acquire mathematical knowledge (information and skills) to understand quantitative aspects of environmental issues and deal with society; learn mathematical skills including number sense; acquire the ability to collect, classify, represent, and interpret numerical data; understand mathematical language such as symbols, terminologies, shapes, and diagrams, etc., to use them in real life; learn numerical, algebraic, and geometrical systems and their properties; understand the nature of mathematics as a system of integrated knowledge; generalize words in numerical procedures (algebra); incorporate mathematics knowledge and experience into other subjects studied; and present results accurately (both written and orally), especially in writing of mathematical proofs.
- *Methodology of thinking and problem solving*: acquire understanding of the mathematical methods and procedures for formulating proofs and the simple basic logical principles; acquire the ability to use different thinking procedures in

numerical, algebraic, and geometrical problem solving; and use scientific thought procedures.

- *Affective (tendencies, values, and attitude)*: acquire positive values toward aspects of mathematics, such as accuracy, organizing, perseverance, objectivity in judgment, respect of others, and correct usage of time; enjoy the beauty of mathematics through discovering the consistency of patterns and samples; develop self-esteem and accept success; and develop confidence in mathematical means and aims.

The Science Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Science Through Eighth Grade

Generally, the national guidelines for the science curriculum[15] in Bahrain emphasize four main areas: science as a cognitive structure, science as a method of research, science as a thinking method, and the relationship between science, technology, and society. Furthermore, the Ministry of Education implemented the guidelines for scientific knowledge concepts for the first and second cycles,[16] which can briefly be divided into the following three areas.

- **Life and environmental science.** The concepts in this area focus on students identifying basic knowledge related to their life and the surrounding environment, beginning with the home, public morals, animals and plants around them, and the tools they use. The concepts are provided in depth and are used extensively in grades where the curriculum exposes students to types of animals and plants, organism classifications, the Earth, agriculture, and the home. It also provides some information about the human body and its organs and principles of public health.
- **Natural science.** This area includes concepts in the natural sciences, particularly those related to physics and chemistry. It covers sound and light; electromagnetic fields; and some information on water, air, and pollution. Also, natural science focuses on chemistry concepts related to substance properties, situations and changes, elements, and mixtures and solutions.
- **Earth and space science.** This area presents some information about the Earth and space, the sun and moon, and the natural phenomenon around us, such as night, day, and the seasons of the year (solar system). It also presents concepts in other areas, such as air pressure, weather, and meteorology.

The conceptual guidelines for the content of the curriculum in science education for the third cycle can be divided into the three following areas.

- **Scientific research.** This area represents research on nature, planning and gathering information, problem solving, and decision-making.
- **Nature of science and history.** This area concerns humanitarian efforts in science, the nature of science, the history of science, the limitations of science, and science globalization.

- **Science, technology, and society.** Within this area, the concepts include the nature of technology, designs and models, scientific innovations, safety mechanisms, quality control, economic values, health and disease, social values, and the environment. Also, aspects of agriculture and food production are presented.

The competency standards for the first cycle, **grades 1–3**,[17] of basic education in science are briefly described below. Students are expected to achieve the following.

- Distinguish basic characteristics of the natural environment; describe living organisms' characteristics, needs, and the types of relationships among them; describe the characteristics of the different types of energy forms; compare substances and describe the changes that can occur in them, including the interaction and the sequence of events in general; use scientific experimental skills in exploring and explaining natural events; and describe some methods of using science in everyday life.

The competency standards for the second cycle, **grades 4–6**,[18] of basic education in science are briefly described below. Students are expected to achieve the following.

- Describe the structure of how the Earth and space are related to each other; search for diversity and balance in environmental systems; describe the relationship between substance properties and their use with different purposes; outline the energy type, source, medium, transmission, and the importance of this on the events and phenomena around them; use tools and the units of measurement accurately; analyze graphs and statistical tables; use scientific procedures in exploring and explaining events around them; design and implement object models for particular purposes, using the appropriate form, dimension, and colors; show the relationships among science, technology, and society; and make decisions about the problems and issues related to science and society based on fundamental knowledge, principles of general science, and scientific processes.

The competency standards for the third cycle, **grades 7–9**,[19] of basic education in science are briefly described below. Students are expected to achieve the following.

- **In earth science**, students should know physical characteristics of the Earth, the processes occurring in its layers, and the pollution issues related to it; have knowledge of the Earth's natural resources, their uses, and how to preserve them; know Earth's location in the solar system; understand the relationships among science, technology, and society, gaining knowledge of their different effects on society and the environment; observe objects from various aspects; become efficient in communicating with others using appropriate tools and procedures; measure and classify objects accurately using appropriate tools; implement scientific experiments and activities using available material from the environment and laboratory; and make judgments on the issues or events in terms of the linkage between observations and relationships.

- **In biology (life science)**, students should know cell types and structure and functions; the relationship between the structure and the function of an organism; human organs, their function, and how to protect them; the reproduction process and genetics; and the internal effects of the external environment on living organisms.
- **In chemistry**, students should know that every substance is made up of tiny particles (molecules), which are in turn built up of smaller particles (atoms); how to classify substances into elements and compounds or mixtures according to their characteristics; the different types of solutions, acids, bases, and salts, their properties, and their usage; and the different changes that might occur on a substance and their causes.
- **In physics**, students should know the physical state of a substance and that changes in state are related to the distance between the molecules of the substance; the concept of energy forms and orientations and that heat transfer occurs when a substance changes states; the nature and characteristics of sound and how to distinguish different types of sound; the basic characteristics and behavior of light and the result from its interaction with objects; the basic concepts of electromagnetism and the dual relationship between forces and particles; and the type of forces and related theories.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Time

The school year in Bahrain consists of 36 weeks, beginning the first week of September and ending in June of the following year. The school year, at all educational stages, is divided into two semesters, each 15 weeks, in addition to 2 weeks for examinations in each semester. There also is a midyear vacation of approximately 2 weeks. The daily school time ranges from 5–6 hours, differing from one stage to another according to the number of periods for each grade. For instance, there is a 6-hour day in secondary schools. Also, the duration of each study period is 50 minutes.[20]

The number of study hours per year is 962 hours for the first cycle, 1,032 for the second cycle, and 1,038 for the third cycle of basic education. Mathematics instruction is 4 hours and 10 minutes per week for the second and third cycles, while in the first cycle, the number of teaching hours depends on the classroom teacher's evaluation. Similarly, the hours for teaching science per week in the first cycle depend on the teacher's evaluation, however, in the second cycle, science instruction is 2 hours and 30 minutes per week, and in the third cycle, it is 3 hours and 20 minutes weekly.

Instructional Materials, Equipment, and Laboratories

The Ministry of Education provides instructional materials free of charge for all government schools. Each student in every class and educational stage receives free textbooks. The ministry also provides private schools with textbooks (free of charge) on Islamic education, Arabic language instruction, history, geography, and citizenship. Textbooks are predominantly produced locally and compiled and printed by the Ministry of Education.[21]

Public schools have all the facilities needed for the teaching-learning process, such as laboratories, learning resources centers, and other facilities, including the following.

- The percentage of schools having computer laboratories reached 80 percent in the 2005–2006 school year, taking into consideration that all secondary- and third-cycle (intermediate) schools have computer laboratories, and there is a plan to establish computer laboratories in all primary schools by 2010.
- The percentage of schools having science laboratories reached 82 percent in the 2005–2006 school year, taking into consideration that all secondary- and third-cycle (intermediate) schools have science laboratories, and there are plans to establish science laboratories in all primary schools by 2010.
- The percentage of public schools having learning resource centers reached 100 percent in the 2005–2006 school year.

Grade at Which Specialist Teachers for Mathematics and Science Are Introduced

The classroom-teacher system is applied in the first cycle of primary education, whereby there is a single teacher for most subjects, except English, design and technology, music education, and physical education. In the second and third cycles, the subject-teacher system is applied, whereby each subject is taught by a teacher who has specialized in a specific discipline.

Use of Technology

Since the 1980s, the ministry has employed information and communication technology (ICT) in the educational learning process in secondary school education. Since 2001, computer use has been a school subject in basic education and ICT has been used to teach school subjects.

Beginning in 2001, the Ministry of Education decided to develop a comprehensive strategy for employing ICT in all educational stages. This goes beyond the mere provision of computer laboratories and the teaching of computer use to the development of a new environment for ICT teaching to meet the requirements of national development and to take advantage of the opportunities offered by major technological developments in this area, especially after the widespread use and development of the Internet. From this strategy, His Majesty, King Hamad, initiated a School of the Future Project in 2005. The goal of this project is adopting ICT in the teaching and learning processes to equip emerging generations with the necessary competencies, skills, and values for the establishment of the information society and a knowledge-based economy. The launching of the project focused on a number of main processes that have led to establishing electronic classrooms, obtaining a multipurpose electronic learning system, connecting electronically schools that are involved in the project, adding electronic classes to learning resource centers, and training teachers to use computers and preparing them to obtain the International Computer Driving License, a certificate that demonstrates competency in computing knowledge and skills in accordance with international standards.

Teachers and Teacher Education

Education and Training for Fourth and Eighth Grade Mathematics and Science Teachers

To be qualified as a mathematics or science teacher for the second and third cycles in the Ministry of Education in Bahrain, teachers must have a Bachelor of Mathematics or a Bachelor of Science certificate, along with a postgraduate diploma in education. For the first cycle, teachers must have a Bachelor in Education from the University of Bahrain or from another country's university that awards the same type of degree. Since the 2004–2005 school year, the Bahrain Ministry of Education started sending students to Jordan to obtain the degree because the education college in the University of Bahrain no longer offered this study option.

The Ministry of Education is working with the Economic Development Board[22] in the planning and implementation of education reform initiatives, aimed at improving the quality of education at local levels. In 2005, both the Ministry of Education and the board worked together to conduct a diagnostic study on education and training in Bahrain. By 2006, the following education reform initiatives had been identified, and were implemented in 2007.

- Developing teacher education and training by establishing a new Teacher Training College and working towards developing other initiatives for school teachers and the selection of administrators.
- Establishing a Quality Assurance Agency, an independent and professional body incorporating the following units: the School Review Unit to conduct regular school evaluations and provide advice on improving student outcomes, including exchanging best practices; the National Examination Unit to administer literacy and numeric national assessments at grades 3, 6, 9, and 12; and the Vocational Review Unit to review vocational institutes, including raising standards and ensuring that training is relevant and sufficient to meet the needs of employers. The agency also conducts regular reviews for all training providers to assess their performance and provide them with advice on areas of improvement.
- Bahrain's TIMSS team plans to implement examinations for fifth and sixth grade students in mathematics and science in 2008 as one of the applications of the study[23] prepared by the team.

In addition, the Directorate of Training and Professional Development is continually introducing programs related to mathematics and science, centered on developing a competency program for mathematics teachers, a competency program for science teachers, and teaching and learning strategies for subject teachers in the basic education cycles. This directorate also is continually introducing technology programs, such as the International Computer Driving License and other programs related to information and communication technology for teachers.

The Bahrain Ministry of Education has a shortage of male mathematics and science teachers, therefore, they annually employ teachers from other Arab countries (the number of female teachers, however, is sufficient).

Examinations and Assessments

National or Regional Examinations

The curriculum for the first and the second cycles of basic education contains compulsory common subjects, including mathematics and science. In this stage, students are assessed through structured observation, daily drills, applications, planned activities, individual and group projects, and mid- and final-semester examinations. Students need a total mark of 50 percent in each subject to pass. If they fail an examination in any given subject, they are permitted to take the examination again, in line with conditions and regulations that the examination system specifies. Repeating the class also is permitted once remedial lessons are taken. If they fail again, they are permitted to take examinations only as an external student. Those who pass the examinations receive the Intermediate Stage Certificate.

The Evaluation and Assessment Center[24] in the ministry has administered the national examination as a first phase in the 2005–2006 school year in mathematics and science for grade 6 students. This examination measured the accumulated skills acquired by students in these two subjects. Similarly, the national examinations were administered in the 2006–2007 school year, as a second phase in mathematics and the Arabic language for grade 3 students.

Suggested Readings

http://www.abegs.org/

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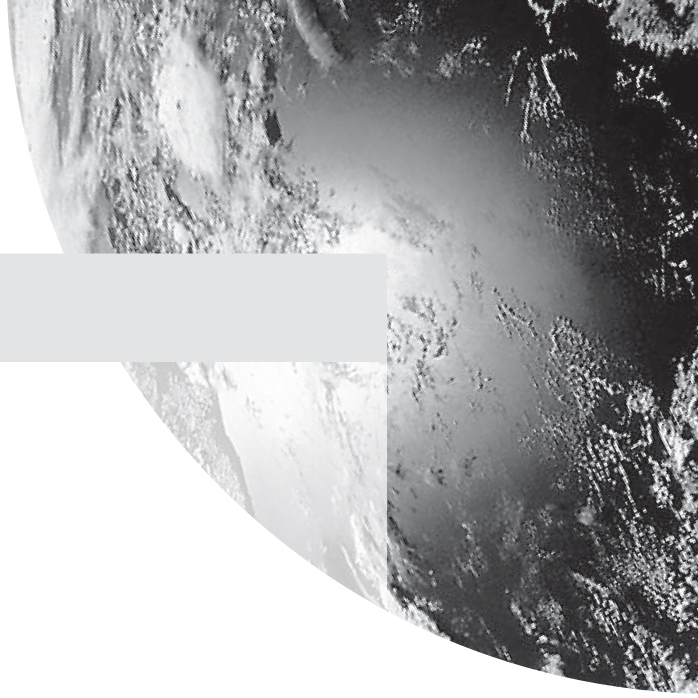

Bosnia and Herzegovina

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Standards and Assessment Agency in Education

Introduction

Overview of Education System

As a country in transition, Bosnia and Herzegovina, has been working toward decentralizing and improving the quality and efficiency of its education. Since the Dayton Agreement (the 1995 peace agreement), there are 12 Ministries of Education in Bosnia and Herzegovina (Republika Srpska, the Federation of Bosnia and Herzegovina, and the 10 cantons or federal units). There also is the Department of Education in the Ministry of Civil Affairs at the state level and a separate jurisdiction for the Brčko district.[1] The Ministries of Education and Science are responsible for education policy in their cantons and in the Republika Srpska. These responsibilities include deciding about education finance, establishing and monitoring education laws and regulations, and administering canton or entity institutions. The shift of educational authority to the cantons means that each canton has the legal right to govern and manage its own education system, including higher education, even though some cantons do not have higher education establishments. Within the Ministry of Education, in seven cantons and in the Republika Srpska, pedagogical institutions carry out the duties of the ministry. The responsibilities of institutes vary slightly, but their main functions include some or all of the following.

- Advising ministries of education on curriculum and new legislation
- Collecting statistical and other information from schools
- Evaluating the quality of schools
- Advising on the appointment of teachers and assessing and confirming their qualifications
- Providing professional development opportunities for teachers and setting up training courses
- Evaluating school development plans.

The Standards and Assessment Agency in Education has been set up with a World Bank loan as a shared inter-entity institution. The objective set for this agency is to provide information to the education community and the public at large on student achievement and overall system performance.

The education system (see Exhibit 1) in Bosnia and Herzegovina consists of preschool, primary, secondary, and higher education. Preschool education is not compulsory and is intended for children up to age 5. Primary school includes 8 or 9 years of compulsory education, varying by canton or the Republika Srpska. Three cantons follow the "old" primary school education structure in which primary education is compulsory for students ages 7 to 14, though parents enroll their children earlier, and it is divided into two, 4-year cycles: classroom teaching from grades 1 to 4 and subject teaching from grades 5 to 8. The other cantons and the Republika Srpska are using the reformed primary school education structure in which there are 9 years of primary school with 3-year cycles, which is followed by either 3 or 4 years of noncompulsory secondary education. The range of secondary schools includes the classic gymnasium and technical schools, as well as 3-year vocational schools that specialize in a broad range of particular trades and occupations.

Exhibit 1 ISCED Levels of Education in Bosnia and Herzegovina

Level 0	Preschool education (Ages: 0–5 or 6)	
Level 1	"Old" primary	Reformed primary
	Lower primary school (grades 1– 4) Ages: 7–10	Primary school, cycles 1 and 2 (grades 1–6) Ages: 6–11
Level 2	Upper primary school (grades 5–8) Ages: 11–14	Primary school, cycle 3 (grades 7–9) Ages: 12–14
Level 3	Secondary school (3–4 years)	

SOURCE: Pašalić-Kreso, A., Muratović, H., Rangelov-Jusović, R., & Trbić, D. (n.d.). *National report-Bosnia and Herzegovina*. Retrieved January 10, 2008, from http://www.see-educoop.net/education_in/pdf/workshop/tesee/dokumenti/book/Bosnia.pdf

There are a lot of reforms in domains such as curriculum design and implementation, education administration, school management, inclusive education, and teacher education and training. In November 2002, the Ministers of Education in Bosnia and Herzegovina signed the document, *Education Reform in Bosnia and Herzegovina*. One of the main objectives of the reform relates to education in preschool, primary, and general secondary education. This law also regulates the standards of education that ensure consistent and efficient implementation of the Common Core Curricula in all schools in Bosnia and Herzegovina. In mid-2004, with the assistance of the international community, a Draft Framework Law on Higher Education in Bosnia and Herzegovina was prepared.[2]

Language and Population

In accordance with the Constitution of Bosnia and Herzegovina, Bosnia and Herzegovina has three official languages and languages of instruction in schools: Bosnian, Serbian, and

Croatian. The languages of all minority populations who live in Bosnia and Herzegovina are respected and included in schools as much as possible.

Overarching Policies Related to Education and the Curriculum for Mathematics and Science
The Standards and Assessment Agency in Education defined competency standards for mandatory curricular areas, including mathematics, biology, chemistry, and physics.

The Mathematics Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Mathematics Through Eighth Grade
The goal of the learning and teaching processes in grade 8/9 is to use definitions, value mathematics as an instrument for describing situations, and develop creative and abstract opinions and conclusions. The expectations for students in these grades are described below.[3,4]

- Compute operations with real numbers, calculate the numerical value of compound expressions, and compose numerical expressions according to a given situation
- Apply the concepts to modeling and solving various problems involving linear equations and systems of two-linear equations with unknowns
- Understand the concepts of linear functions and their properties
- Understand and apply the basic concepts of proportionality and geometric relationships
- Explore transformations and solve problems using geometric models (such as using two- and three-dimensional geometric shapes in real-life situations)
- Link mathematics content to other domains.

The Science Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Science Through Eighth Grade
Upon completing the eighth/ninth grade, students should be able to do the following.[5]

- Explain the path of human species development
- Demonstrate knowledge of structure and function of the human organism
- Understand sexuality as part of human life
- Understand human relations between sexes
- Identify how knowledge of heredity and reproduction can improve the quality of life
- Demonstrate knowledge about mechanical, electrical, magnetic, and optical phenomena and understand and apply methods of physics in solving problems in these domains
- Encourage students to explore nature and prepare students to notice the harmony of nature

- Demonstrate knowledge of characteristics of matter and chemical changes, the chemical structure of the Earth, properties of metals, categories of compounds, and properties of organic compounds
- Evaluate the potential use of natural resources for technology and the consequences of human use of natural resources
- Understand ethical relations among human beings and relations between human beings and the environment.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Time

According to the curriculum, students in grades 8/9 receive 28 to 30 hours of instruction per week. A single lesson lasts 45 minutes.

Instructional Materials, Equipment, and Laboratories

For each grade in primary school, there are two or three textbooks that teachers can choose to use, with the exception of the Republika Srpska where there is one textbook for each subject approved by the ministry. Worksheets and different collections of mathematics and science assignments are available for teachers and students that follow the content of the textbooks.

Grade at Which Specialist Teachers for Mathematics and Science Are Introduced

In the Bosnia and Herzegovina education system, schools have subject area specialist teachers for mathematics and separate science subjects mostly starting in fifth grade. These areas are periodically evaluated by the Standards and Assessment Agency in Education.

Use of Technology

The use of modern technology is a recent development in primary school. This initiative has been supported by various international donors and Ministries of Education.

Teachers and Teacher Education

Education and Training for Fourth and Eighth Grade Mathematics and Science Teachers

Since all teachers in Bosnia and Herzegovina are government employees, they have to take a professional exam in addition to acquiring the appropriate diploma in order to qualify to work in public and private schools.

Teaching in the first three or four grades of primary schools is carried out by classroom teachers, while in the upper grades of primary school, it is carried out by subject teachers or secondary school teachers. Teaching personnel for the lower primary school grades (from first to fourth grade) undergo four years of education at the Academies of Pedagogy and Pedagogical and Teachers' Faculties. Teaching personnel for the higher primary school grades typically complete two or four years of education at the Teachers' Faculties. Teachers of eighth grade mathematics and science are required to participate in a 4-year higher education program at the faculties of mathematics and the faculties of science (geography, biology, chemistry, and physics) that also offer pedagogical training as part of their specific discipline. All new teachers are obliged to gain 1 year of experience working in schools and then to take the professional examination for independent educational work, which will qualify them to work in the schools. Professional examinations are carried out by education ministries with the assistance of pedagogical institutes.

The transition to a compulsory 9-year education, inclusion of children with special needs into the mainstream education, the introduction of new subjects, and the review of the existing curriculum are only some of the changes that brought teachers a multitude of new challenges and, as such, increased the requirements concerning their initial and continued education and training.

Teacher Professional Development in Mathematics, Science, and Technology

Teacher professional development and advancement is regulated by legislation at the entity level in the Republika Srpska and the cantonal level in the Federation. The Brčko district has its own legislation. Decisions concerning professional development are issued in a centralized manner, at the ministerial level (i.e., the pedagogical institute level). Apart from the pedagogical institutes, there are no specialized institutions for professional development of teachers or active teachers' associations at the entity or state level. Teachers are obligated to develop professionally through the collective or group and/or individual forms of professional development. The collective or group development includes attending exemplary or experimental lessons; involvement in the activities of the expert school bodies; and attending consultations, seminars, conferences, etc. A certain number of teachers attend compulsory training programs organized by the ministries (i.e., pedagogical institutes) during summer or winter holidays.[6]

The monitoring and assessment of teachers, which is carried out by counselors or inspectors, is in a transitional phase. Work also is being done to develop uniform standards for teachers.

Examinations and Assessments

National or Regional Examinations

The first national assessments of achievement in mother tongue language (Bosnian, Serbian, and Croatian) and in mathematics were administered at the end of grade 4 in 2002 and grade 8 in 2003. The goal of these assessments was to provide the educational administration, professional institutions, schools, and teachers with valid data about required skills for fourth and eighth grade students and to determine what students actually have learned, what they have been trained for in terms of the practical use of the acquired knowledge, and how and under what conditions the teaching process was performed. The assessments are administered to representative samples of schools and students.[7] In 2006, evaluation tests of learning achievements in physics, chemistry, and biology were administered in the final grade of primary school. The instruments were based on the curricula presently in use in the Federation of Bosnia and Herzegovina and in Republika Srpska.

The national assessments are repeated on a 4-year cycle, with two or more subjects assessed each year. Unfortunately, Bosnia and Herzegovina still does not have a specialized institution for diagnostic tests. Most teachers still use their own experience and knowledge to monitor students' abilities and progress.

Monitoring Individual Student Progress

Students are assessed by their teachers based on a regulated assessment procedure. Student achievement is assessed continuously in written, oral, and applied forms. During the school year, teachers collect information about each student's performance through observations, completed student work, and school-wide tests. Students receive numerical grades. For evaluation of student achievement in grade 8/9, numbers from 1 to 5 (1 = failing grade, 5 = excellent) are used as summative marks.

Grade Promotion and Retention Policies

In primary school, automatic promotion is used with a low rate of grade repetition.

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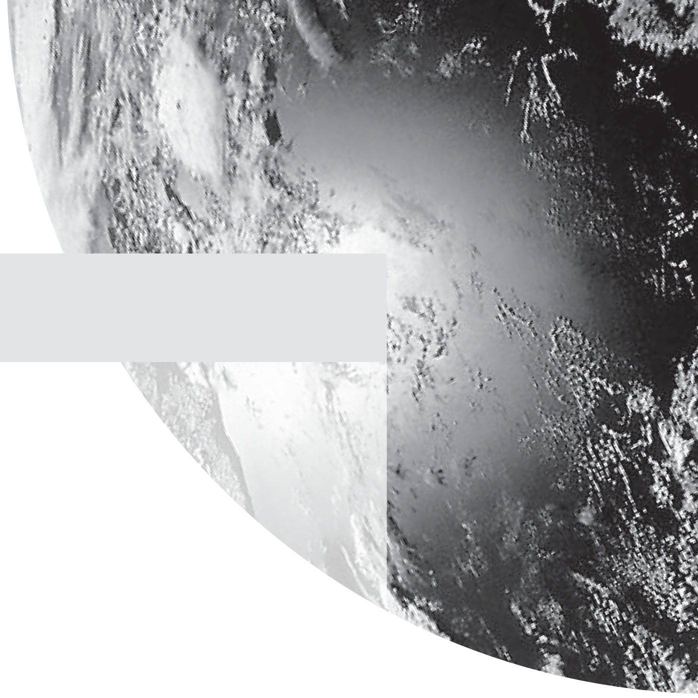

Botswana

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Introduction

Overview of Education System

At the primary level, Botswana's education system is the joint responsibility of two ministries, the Ministry of Education and the Ministry of Local Government. The Ministry of Education is responsible for teachers, the curriculum, and support services while the Ministry of Local Government is mainly responsible for the provision of infrastructure and the supply of stationery and recommended textbooks. The Ministry of Local Government carries its responsibilities throughout the nine, main local authorities called districts, which are subdivided into 28 subdistricts. The Ministry of Education's responsibilities for the provision of teachers and the curriculum are primarily carried out centrally whereas the support services provided by the inspectorate and teacher professional development are decentralized.

Secondary and tertiary education are administered by the Ministry of Education. Education funding comes mainly from the government. Expenditure on education has steadily increased over the past years. According to the 2007–2008 national budget, the Ministry of Education was allocated 28 percent of the ministerial recurrent budget and 8 percent of the development budget.[2]

Botswana has a national curriculum under the Ministry of Education's Curriculum Development and Evaluation Department. The curriculum goals are derived from the education policy. The department has officers responsible for each subject. Each subject officer makes use of committees/task forces comprised of teachers, education officers, university or college lecturers, and other stakeholders to develop teaching syllabi for each subject in the curriculum and also to prescribe the best books in the market that address the syllabus for each subject.

Botswana provides a 7-3-2 structure of education: 7 years of primary education, followed by 3 years of junior secondary education and, finally, 2 years of senior secondary education. The 7 years of primary education consists of 4 years lower primary and 3 years upper primary. Senior secondary education marks the end of pre-university education.

Grades 1 to 10 form the basic education cycle. The entry age is officially 6 years old, but some children may start later due to various factors such as the type of settlement they reside in. For a long time, preprimary education in the country was provided by private individuals and organizations registered with the Ministry of Education. It did not have a standardized or set curriculum, but most of the providers offered elements that were both social and academic in nature. However, the government is currently working on this area with the intent of linking preprimary education to formal schooling. This is in pursuit of recommendation 9(c) of the *Revised National Policy on Education of 1994*, which states that the "Pre-primary Education unit should be established as soon as possible in the Department of Primary Education with the functions of registering all pre-primary education units, establishing standards of facilities and the quality of the programme and supervising pre-primary education." [3]

Most of the schools in the country are owned and run by the government. In the primary section, only about 8 percent of the schools are private. The corresponding percentage in the secondary section is approximately 13 percent.[4] For almost 19 years, education has been offered for free in the government schools. Beginning in 2005, parents began contributing 5 percent of the total expenditure for the secondary education of their children. Primary education remains free for citizens.

Private schools are owned and run by individuals or organizations but are registered with the Ministry of Education. The main source of funding in these schools is the fees that parents pay. Most of the private primary schools design their own curriculum, which is more advanced than the one offered in government schools. Private secondary schools mostly offer the International General Certificate of Secondary Education.

The commitment to providing lifelong quality education to all school-age children remains a challenge for Botswana. According to the last population census in 2001, about 9 percent of school-age children were not in school for reasons that were unknown.[5] Although, overall, the country has done well quantitatively in the provision of education since the 1977 Education Policy, the issues of quality in education and low achievement levels remain challenges within the system. The *Revised National Policy on Education* takes this into account and states that:

> As a result of the adoption of the National Policy on Education in 1977, educational development has been characterised by a massive expansion of school places…However, although not by design, the success in quantitative development of the school system has not been adequately matched by qualitative improvements.[6,7]

Language and Population

English and Setswana are the two official languages in the country, though there are other languages spoken. English is the medium of instruction in the education system beginning in grade 2. The exception is private English-medium schools where instruction in English begins in preschool. Setswana is a compulsory subject for students from grade 1 to senior secondary education.

Emphasis on Mathematics and Science

The government of Botswana attaches great importance to mathematics and science such that the subjects are core at both primary and secondary education. In fact, the *Revised National Policy on Education* has determined that mathematics and science are critical if the country is to move from an agro-based (agriculture-based) economy to a more industrial one.[8] This importance also is articulated in recommendation 43(d) of the same policy which states that:

> Intensified measures to popularize Science amongst students and to develop an interest and positive attitudes towards Science and Technology should be developed through Science and Mathematics fairs and other competitive activities, special awards, the establishment of a Science and Technology park and so forth.[9]

Overarching Policies Related to Education and the Curriculum for Mathematics and Science

Since Botswana first participated in TIMSS in 2003, the Ministry of Education has given increased attention to the teaching of mathematics and science. One such initiative in this endeavor is the project Strengthening Mathematics and Science Education, which is an intensive professional development program aimed at improving instruction in mathematics and science. The recommendations from the *TIMSS 2003 National Report*[10] were considered heavily in the current revision of the grade 8 to 10 mathematics and science syllabi.

In its efforts to encourage students to take an interest in mathematics and science, the government of Botswana offers grants for university education to those students interested in following careers in mathematics and science. Currently, the government also is setting up a second university solely to offer science- and technology-based courses.

The Mathematics Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Mathematics Through Eighth Grade

The mathematics curriculum in Botswana consists of five areas: number, measures, algebra, geometry, and data and chance. According to the national curriculum, students should have been taught each of the following topics or skills by the end of grade 8.[11,12,13]

- *Number:* basic operations on whole numbers including directed numbers and ordering and comparing directed numbers; approximations and rounding; classification of numbers; representing numbers in words and numerals; factors and multiples; basic properties of operations on whole numbers; order of operations; calculator use; the four basic fraction operations; comparing and ordering of fractions; number patterns and sequences; the four basic decimal operations; place value, comparing and ordering, converting to common fractions (and vice versa), and rounding; conversion of percents to fractions or decimals and vice versa; basic operations involving money and percentages including discounts, profits and losses, and percentage of profits and losses; and civic arithmetic including bills and invoices.

- *Measures:* measures of length, area, volume, mass, and time; estimation of measures of length, area, mass, and angles; perimeter of triangles, quadrilaterals, and composite shapes; area of triangles and quadrilaterals; relationships between days, weeks, and months; and 12–hour and 24–hour clock systems and simple timetables.
- *Algebra:* terms and expressions; simplifying algebraic expressions; expansion and factorization; evaluating expressions and formulae for a given numeric value (substitution); and forming and solving linear equations from real-life situations.
- *Geometry:* right, straight, obtuse, and reflex angles; relationships of angles at a point, angles on a line, vertically opposite angles, angles associated with a transversal cutting, and parallel lines and perpendicularity; properties of polygons; sums of interior and exterior angles and line and rotational symmetry; addition and subtraction of column vectors and scalar multiplication of vectors; and translation, reflection, enlargement, and rotation.
- *Data and chance:* the interpretation, organization, and display of data using tables, pictographs, bar graphs, pie charts, and line graphs.

The Science Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Science Through Eighth Grade

According to the national science curriculum, students should have been taught each of the following topics or skills by the end of grade 8.[14,15,16]

- *Environmental science:* living and nonliving things; care of the surroundings; the sky, seasons, weather, and the solar system; natural resources; ourselves and other animals; personal hygiene; the nature of science; the history of science; the environment; plants including its parts and functions; technology in science; storage, conservation, sources, and uses of water; and the air.
- *Biology:* first aid and safety awareness; skeletal, nervous, digestive, circulatory, and reproductive body systems; physical development, human reproductive system, sexually transmitted diseases, HIV and AIDS, teenage pregnancy, and methods of birth control; characteristics and classification of living things; plants and animals; cells including tissues, organs, and systems; food sources, nutrients, digestion, and deficiency diseases; food poisoning and the preservation, storage, and handling of food; caring for teeth; the nature of blood, blood groups and blood transfusions, and heart and circulatory problems; drugs and alcohol including their use, misuse, and abuse; photosynthesis and respiration; transport of food, water, and nutrients into plants.
- *Chemistry:* matter, energy, and chemical reactions, states of matter, and changes of states.

- *Physics:* force, levers, and simple machines; static electricity, current electricity, magnets, and electromagnetism; process skills and applications of science in everyday life; measurement (length, area, mass, volume, density, temperature, and time); sources of energy, energy changes, and conserving energy; the nature, characteristics, and properties of sound, propagation of sound, the ear, ear defects and deafness, and applications of sound.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Time

Mathematics is introduced into the first primary grade, while teaching of formal science begins at the fifth primary grade. In grades 1 through 4, children are only exposed to environmental science education. It is the policy in government schools that students should be taught in mixed ability groups for all subjects.

At the primary school level, instructional time for mathematics is 3 1/2 hours a week and 3 hours for science. Junior secondary instruction for mathematics is 3 hours and 20 minutes and about 3 hours a week for science. These time allotments are set by the Department of Curriculum Development and Evaluation.

Instructional Materials, Equipment, and Laboratories

Instructional materials, including prescribed textbooks, teacher's guides, and supplementary materials at each grade, are used to enrich and explain the curriculum. Textbook activities include self-learning skills, active learning, and exercises for consolidation purposes. The materials are developed by independent publishing companies and then presented to the Department of Curriculum Development and Evaluation, which then evaluates them to select those that best address each syllabus. The department accomplishes this by engaging task forces of teachers and education officers who are conversant with the syllabus requirements.

Some schools, especially private ones, are well resourced with the essential equipment and laboratories. In government schools, laboratories are provided at junior secondary level and beyond, while none are provided at the primary school level.

Grade at Which Specialist Teachers for Mathematics and Science Are Introduced

Historically primary school teachers were responsible for instruction in all subjects. Beginning in May 2007, a pilot project began to incorporate specialist teachers at the primary school level. This is following the *Revised National Policy on Education* recommendation 23(c), which states that, "from standard 4 onwards pupils should gradually be introduced to teaching by specialist teachers." [17]

In the pilot project, mathematics and science are taught by teachers who specialize in these subjects. The pilot covers grades 4 to 6 and will be extended to include grade 7 in subsequent years. Thus, grades 4 to 8 will eventually be taught by specialist teachers. (Grades 8 to 10 have always been taught by specialist teachers.)

Use of Technology

All children are mandated to take a basic computer awareness course in the junior secondary phase of education. Not all schools are equipped yet with computers and computer labs, however, efforts are being made toward this goal. The use of technology for instructional purposes is not a common feature in public schools. However, the government intends to pursue this. The following recommendations from the *Revised National Policy on Education* indicate the government's intentions towards strengthening the use of technology:

> Techniques of using technology to teach technology [should] be encouraged. This calls for teachers to avail themselves of technology based teaching aids on the one hand, and on the other hand for students to be exposed to the practical application of Science and Technology and to gain hands-on experience of them.[18]

> The formulation of a Science and Technology policy should be finalized as soon as possible, and that the policy should pay special attention to providing guidelines for Mathematics and Science education.[19]

Teachers and Teacher Education

Education and Training for Fourth and Eighth Grade Mathematics and Science Teachers

Teachers must complete a 3–year diploma course at a primary college of education to teach in a primary school or secondary college of education to teach in a junior secondary school. However, there are some primary school teachers who previously qualified when a 2–year teacher training certificate was the minimum required. Currently, these teachers are being upgraded in phases so that eventually, at a minimum, diploma holders will be teaching in these schools. During their study at the secondary colleges, prospective mathematics teachers spend about 58 percent of their time on content and about 42 percent on pedagogy while for science it is 75 percent and 25 percent, respectively. In primary colleges of education, 50 percent of time is spent on content and the other 50 percent on pedagogy for the two subjects.

In addition to academic and pedagogical studies, prospective teachers have a 6 week course where they practice teaching in schools under the supervision of experienced teachers. The college lecturers also visit them to make an assessment, which eventually forms part of the final grade of the prospective teacher.

Before the late 80s, the country's historical shortage of mathematics and science teachers was remedied by recruiting expatriates in secondary schools. This came to an end when secondary colleges of education started producing teachers to supplement those from the single local university, which was the sole institution for the training of secondary school teachers.

Teacher Professional Development in Mathematics, Science, and Technology

The Ministry of Education's Department of Teacher Training and Development is mandated to provide professional development to teachers for school subjects across the curriculum, including mathematics and science. Currently, the department is suffering a great shortage of officers for the successful execution of this mandate. The findings of TIMSS 2003 actually proved this in some way, since the majority of teachers in the sample indicated that they do not participate in professional development activities[20] though they were not probed further to find out why.

Examinations and Assessments

National or Regional Examinations

Students take various national examinations throughout their formal schooling. These serve various purposes other than enhancing the teaching and learning of the curriculum. The Standard Four Attainment Test that covers mathematics and the Setswana and English languages is administered at the end of grade 4. The purpose of the test is to check progress in learning achievement so that appropriate action, in terms of either retaining or promoting the child to the next grade can be taken. At the end of grade 7, students at both private and government schools students take the Primary School Leaving Examination. Historically, this examination was used for selecting those who would proceed to junior secondary education. This is no longer the case since the 10 years of basic education extends to the end of junior secondary education. The assessment now has become a diagnostic examination, informing schools, districts, and other stakeholders of strengths and weaknesses. At the end of grade 10, students sit for the Junior Certificate Examination that is used for selecting those who will proceed to senior secondary. Some of those who do not make it into senior secondary may take the vocational education path, while others may enter the employment sector. Similarly, the Botswana General Certificate of Secondary Education, taken at the end of grade 12, is used to select students for entrance into university, colleges of education, and many other tertiary institutions.

Monitoring Individual Student Progress

Teachers and schools monitor the progress of individual students through marks and report cards. For each school, term report cards are prepared with marks allocated for each subject and sent to parents. Occasionally, parents are invited to schools where they will receive reports and discuss their child's progress with the teachers. Remedial programs are offered under school supervision.

Grade Promotion and Retention Policies

Apart from retention at grade 4 described previously, the country practices automatic promotion from grades 1 to 4, grades 5 to 10, and 11 to 12. However, the *Revised National Policy on Education* calls for a change of this policy since recommendation 23(a) states that, "The policy of automatic promotion should be replaced with a policy of assessed progression."[21]

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1 The five authors of this chapter are members of the Botswana Examinations Council Officers from the various departments of the Ministry of Education also assisted in the collection of the information used in this chapter. Also, the following members from the Botswana Examinations Council made contributions in the form of editing and proofreading: Monamodi Kesamang, Trust Masole, and Moribola Pharithi.

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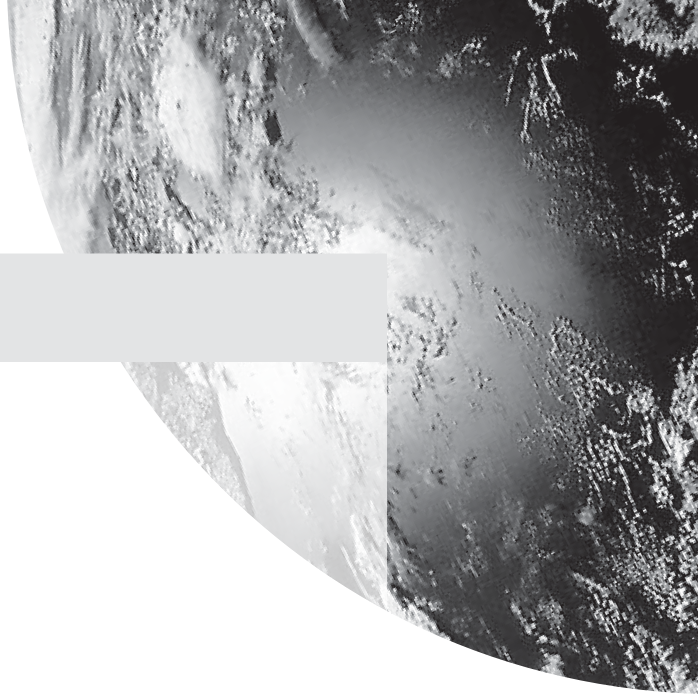

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Introduction

Overview of Education System

The administration of education in Taiwan is based on one unitary system and includes the Ministry of Education in the central government and the Bureau of Education in the local government. Depending on this administrative division, the functions and authority of these two government organizations are different. Before the 1990s, the educational policy of the local government was governed by the central government. Since then, in order to meet social changes, local government's authority in autonomously instituting the policy of education was increased.[1,2]

Formal education forms a hierarchical system from preprimary school to the university, including 9 years of compulsory education. The total time to complete formal education is flexible, but it normally includes 2 years of preprimary school, 6 years of primary school, 3 years of junior high, 3 years of senior high school, and 4–7 years of college or university. The compulsory education program, implemented in 1968, is composed of grades 1–9 (primary school and junior high school), however, the central government presently is evaluating the possibility of implementing 12 years of compulsory education. After college or university, advanced education programs toward either a master's degree (1–4 years) or a doctoral degree (2–7 years) are optional. Also, students with physical or mental disabilities can voluntarily choose a special education program, which is parallel to all levels of formal education.

Because of social changes since the 1990s, a majority of people proposed the need of educational reform. After the announcement of the Education Basic Law on June 23, 1999, many initiatives of education reform have been carried out.[3] Among them, the implementation of the Integrated Curricula for Grades 1–9 and Multi-route Promotion Programs exerted the major influence on educational practice.[4]

Educational reforms began in the 1990s. Before that, the curriculum in elementary and junior high school was not integrated. Each curriculum was developed by different institutes. In order to eliminate the discrepancies between them, the education authority invited experts in education, as well as in other subject-related areas, to organize a more coordinated and integrated framework of the curriculum for grades 1–9. The Grade 1–9 Curriculum Guidelines, which is based on this framework, was implemented in first grade in 2001 and in all grades in 2004.

In Taiwan, as well as in other Asian countries, such as Japan, Korea, and Singapore, an academic degree has extraordinary value. Therefore, in order to reduce both students' and parents' burden, Multi-route Promotion Programs also were implemented in 2002, parallel to the Grade 1–9 Curriculum Guidelines. The evaluation of the efficacy of the Multi-route Promotion Programs in educational practices is still ongoing. The details of these programs will be discussed at the end of this chapter.

Language and Population

The population of Taiwan is 23 million. Most of the inhabitants are the descendants of immigrants from mainland China, particularly those from the southeastern coastal provinces of Fujian and Guangdong. There are 360,000 indigenous people who can be distinguished into 13 different tribes: the Amis, the Atayal, the Paiwan, the Bunun, the Puyuma, the Rukai, the Zou, the Saisiyat, the Tau, the Sao, the Kavalan, the Truku, and the Sakizaya.[5]

The official language of Taiwan is Mandarin Chinese, but many people also speak Min-nan (the southern Min dialect or Holo). Smaller groups of Hakka people and aborigines still preserve their own languages. Many elders also speak Japanese if they were educated during the period in which Taiwan was colonized by Japan before 1945.

In primary and secondary schools, Mandarin Chinese is the language of instruction, except for those courses that teach Taiwanese dialects and foreign languages. The most widespread foreign language in Taiwan is English, which is a part of the regular school curriculum.

Emphasis on Mathematics and Science

The Ministry of Education and the National Science Council convened the First National Congress on Science Education on December 20–21, 2002. The committee of the congress was composed of experts in mathematics and science education. Based on their consensus, the ministry published the White Paper on Science Education,[6] which is the blueprint to improve science education and related policies in the nation.

In light of the White Paper on Science Education, the short-term prospects of science education include the following.

- Coordinate related units of government in properly distributing budgets and implementing various policies
- Prioritize the goals of science education on the basis of the demands of education, social change, and globalization
- Enhance the relevance among different practices of science education and correspondence to the goals of science education

- Evaluate the implementation of science education and provide the basis for the review of policies and their modification.

The long-term prospects of science education include the following.

- Legislate laws that regulate the organizations, personnel, procedures, and budgets for science education policies
- Modify and propose the executive guidelines through related academic research and evaluation
- Cultivate experts in science education policy and science education administration.

In addition, the White Paper on Science Education suggests giving priority to the following.

- Establish the criteria for excellence of science education in order to evaluate the accountability of government units for promoting science education
- Organize the teaching material center to conduct research and meet the goals, content, and spirit of the national standards of science curriculum
- Invite researchers in science education and special education to investigate the learning characteristics of students with low science achievement or those who have physical and mental disabilities
- Fund the budgets from the National Science Council and Ministry of Education for promoting popular science education
- Enhance cooperation between the National Science Council and Ministry of Education to sponsor the integration of related research on science education practice
- Establish research centers of science education to promote high-quality research on science education
- Establish the national committee of evaluation of science teacher cultivation.

The Mathematics Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Mathematics Through Eighth Grade

The curriculum in grades 1–9 encompasses seven major learning areas: language arts, health and physical education, social studies, arts and humanities, mathematics, science and technology, and integrative activities. The goals of the Grade 1–9 Mathematics Curriculum Guidelines include the following.

- Develop algorithm, abstract reasoning, inferencing, and communication abilities
- Develop word problem-solving skills
- Develop the basic ability for learning advanced mathematics
- Develop the attitude for appreciating the beauty of mathematics.

The curriculum guidelines specify five mathematics strands administered according to the grade level: number and quantity, geometry, algebra, statistics and probability, and mathematical connection. The indicators of corresponding competence, based on the cognitive development of students and the relations within a strand and across strands in grades 1–9 are provided in the curriculum guidelines.[7] The objectives of the five strands are briefly sketched below.

- **Number and quantity.** School mathematics mostly depends on number and quantity. In elementary school, students are expected to master the operations of natural numbers; understand the concepts of time, distance, area, weight, volume, capacity, angles, and the units to measure them; understand that fractions and decimals may refer to parts of a set or parts of a whole; and use estimation strategies in computation, problem-solving, and checking computations. In junior high school, the concepts of negatives, the operations of integers and rational numbers, the geometric meaning of the absolute value, concepts of prime and composite number, and concepts of arithmetic and geometric sequences are included.
- **Geometry.** Geometry is the study of space and figures in space. In grades 1–3, students should be able to process the identification, exploration, and operation of geometric figures. In grades 4–5, students are expected to utilize quantities to express relationships among the geometric components. In grades 6–7, spatial and visual reasoning are developed. In grades 8–9, plane geometry is studied, both as an introduction to the concept of mathematical proof and as a fascinating structure.
- **Algebra.** Algebra is important for solving equations and inequalities. Students learn to solve problems using symbolic representation. In elementary school, students learn to express verbally and in sentences that stand for equations and know how to evaluate algebraic expressions and solve simple linear equations. In junior high school, students should be able to use equations or inequalities to represent the relationships among the quantities described in questions; solve the linear equation of one variable, the simultaneous linear equations of two unknowns, and the linear inequality of one variable; factorize a polynomial; and solve a quadratic equation, as well as understand the geometric meaning of the linear function and the quadratic functions.
- **Statistics and probability.** Students are provided with an introduction to the concept of probability, interpretation of data, and fundamental statistical problem solving. This strand has strong connections with algebra, as well as with number and quantity. In elementary school, students mastering this academic content will be able to build and understand the simple statistics tables and utilize a pie chart to represent the statistics information. In junior high school, students are expected to understand definitions of the accumulative frequency and the mean, median, and mode of a distribution of data and utilize computers and software to compute them, as well as make statistics tables and graphs.

- **Mathematical connection.** In order to make students learning meaningful, this strand emphasizes the integration among the four strands mentioned above and the transfer of mathematical knowledge and reasoning from school to daily life, as well as to other subjects such as science and technology.

The Science Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Science Through Eighth Grade

The goal of the science curriculum is to increase civil science literacy. Science literacy includes eight domains: knowledge development of science and technology, science process skills, development of processing intelligence, scientific applications, designing and making, understanding the nature of science, understanding the development of science and technology, and development of scientific attitudes. In the learning area of science and technology, the learning processes for grades 1–9 consists of four stages: stage 1 (grades 1–2), stage 2 (grades 3–4), stage 3 (grades 5–6), and stage 4 (grades 7–9). The competence indicators for students in the four stages are listed separately in the Grade 1–9 Science and Technology Curriculum Guidelines.[8] The objectives of science learning in eight domains are described briefly below.

- **Knowledge development of science and technology**. The content of knowledge to be developed includes five themes: the composition of the natural world and its features, actions of the natural world, evolution and continuity, life and the environment, and sustainable development. Each theme has several topics. For example, in actions of the natural world, there are three topics: changes and equilibrium, structure and function, and interaction. Each topic contains some subtopics. For example, structure and function consists of the structures and functions of plants and animals.
- **Science process skills**. Science process skills refer to the executive skills of conducting scientific inquiry when the problem is well defined. Except for problem finding and evaluation (described in the domain of processing intelligence), the science process skills include five facets: observation (recognizing meaningful signals and measuring quantitatively), comparison and classification (knowing the attributes of different variables and controlling variables), organization and connection (solving causal relations through evidences), induction and inference (explaining data), and communication (acquiring information by a variety of mediums, stating clearly and scientifically, and expressing oneself appropriately).
- **Development of processing intelligence**. Processing intelligence refers to the synthesizing abilities of scientific thinking that are used to define, deal with, develop, and evaluate problems. It comprises five facets: comprehensive thinking (forming integrated points of view through related information); inferential thinking (making prediction based on scientific rules and theories); creative thinking (finding solutions from different perspectives, facing challenges flexibly, and acting with reflection); critical thinking (finding the possibilities to

improve the present situation by comparing the reality to the ideal or theoretical conditions); and problem solving (facing up to problems and planning and evaluating methods and strategies).

- **Scientific applications**. Scientific applications means utilizing the scientific methods and knowledge learned in the classroom to solve daily-life problems. Scientific methods involve the operation of machines and instruments, the planning of inquiry activities, the decision-making process, etc. This domain emphasizes the transfer of problem situations from school to daily life.
- **Designing and making**. Designing refers to identifying people's needs and conceiving a way to satisfy those needs. Making means using technical and practical knowledge to choose adequate tools and materials to create products that satisfy the needs of the designer.
- **Understanding the nature of science**. The nature of science refers to the properties of science knowledge and research activities. Students are expected to reflect on their science learning experiences, know the existence of natural laws, and master the ways of argumentation in science. The ways of argumentation require students to differentiate evidence from theory, consider the internal consistency of explanations, and build up the relationship between evidences and theories.
- **Understanding the development of science and technology**. The development of science and technology concerns the creation and change of technology and the relationship among science, technology, and society. This domain has three facets: the nature of technology (recognizing the importance and characteristics of technology and the relation between science and technology); the evolution and advancement of technology (knowing technology in agricultural, industrial, and the information age and trends of technology development); and technology and society (making sense of the way technology interacts with our life, the relation between technology and individual career planning, the interaction between the development of industry and technology, etc.).
- **Development of scientific attitudes**. Scientific attitudes covers three facets, respectively, that are emphasized in different learning stages: the preference of carrying out explorations (stage 1, grades 1–2), enjoying the joy of discovery (stage 2, grades 3–4), carefulness and tangibility (stage 3, grades 5–6), and being precise and realistic (stage 4, grades 7–9).

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Time

According to the General Guidelines of Grades 1–9 Curriculum of Elementary and Junior High School Education, there are 200 school days during a school year, and students have to attend school 5 days a week. The learning periods include the periods of subject area learning and alternative learning. For fourth graders, there are 25 periods of subject area learning a week and for eighth graders, 28 periods. The periods of science and technology and mathematics in fourth and eighth grade constitute approximately 10–15 percent of the subject area learning periods. In general, the duration of each period lasts 40 minutes in elementary schools and 45 minutes in junior high schools. However, regarding the actual curriculum implementation and needs of students, the Committee of School Curriculum Development in each school may adjust the learning periods for each subject area, the duration of each period, and the number of weeks during a semester.[9]

Instructional Materials, Equipment, and Laboratories

From 1968 to 1995, all textbooks in mathematics and science for elementary schools and junior high schools were published by the National Institution of Compilation and Translation, which is a subdivision of the ministry. Following the adoption of Article 8.2.1 of the 1995 National Education Law, which stated that "all the textbooks for elementary and junior high school students have to be approved by the educational authority and if necessary, the educational authority could publish the official version of textbook." As a result of this act, teaching materials can be edited and published by private publishers and by the National Institution of Compilation and Translation. Since 1996, the curriculum development committee in every school can regulate the teaching materials from various versions of textbooks approved by the ministry.

Use of Technology

Policy-makers noticed that the increasing application of technology in education benefits teaching and learning. The ministry announced the Blueprint for Information Education for Primary and Secondary Schools in 2001 to encourage the application of information technology in subject area learning for elementary and secondary students.[10]

Teachers and Teacher Education

Education and Training for Fourth and Eighth Grade Mathematics and Science Teachers

In Taiwan, three types of preservice teacher education programs are available at the level of higher education—the training for teachers of secondary schools and institutions, for elementary schools, and for kindergartens. Before 1994, primary school and high school teachers were educated only in normal schools, normal colleges, and normal universities.[11] In 1994, the Teacher Education Law replaced the Normal Education Act. Since then, the policy of preservice teacher education has changed, and normal schools are no longer the only institutions to train teachers. Universities also may offer educational curriculum and postgraduate credit programs on education and participate in the training of teachers of kindergarten through senior high school.

According to the Teacher Education Law, amended in 2003, the three kinds of institutions for teacher cultivation are normal universities, education-related departments, and teacher education centers in universities.[12] A qualified teacher has to pass the certification of qualification after taking the preservice teacher education program. In this program, discipline courses, education professional courses, and a half-year practicum are obligatory. The goal of the discipline courses is to develop teachers' professional knowledge and skills in one specialized area of teaching subjects. Education professional courses refer to the pedagogical and pedagogical content-specific courses. For most learning areas in junior high schools, preservice teachers need to take the discipline courses for approximately 30–40 credit hours and the education professional courses for 26 credit hours. For preservice teachers of elementary schools, the discipline courses are not necessary, but 40 credit hours of education professional courses are needed, which includes the obligatory pedagogical content-specific courses for three to four different areas of teaching subjects. The curriculum of the discipline courses and education professional courses have to be approved, both by the committee of teacher cultivation in every university and by the ministry. As for the practicum, the total duration is 6 months.

Teacher Professional Development in Mathematics, Science, and Technology

The institutions of preservice teacher cultivation also are responsible for the further education of teachers. According to the Regulations of In-service Education for Grade K-12 Teachers, both elementary school and secondary school teachers were required to take teacher professional development programs for a total of 90 hours every 5 years at the minimum. However, these regulations were abolished in 2003, and since then the Bureaus of Education of local governments have regulated teacher professional development programs.

Examinations and Assessments

National or Regional Examinations

Due to educational reform, the Joint Public Senior High School Entrance Examination, an achievement test, was abolished in 2001. This examination was the main channel for junior high graduates to get into senior high schools over the past decades. Since 2001, scores on the Basic Competency Test for junior high school students, which is given twice a year, are used as the main criteria by senior high schools to select their approved students.[13]

The subjects of the Basic Competency Test cover Chinese, English, mathematics, natural science, and social science. This test emphasizes students' fundamental knowledge and skills. The score of the first Basic Competency Test can be used to apply to the school that the student chooses. If he or she fails the test after taking it the second time, the better score of the two scores is used as the criterion for students' entrance into a senior high school.

In addition to the system of senior high education, the Practical Technical Program provided by vocational schools is available for students who want to begin their professional career at an early age.[14] One year of technical training courses is offered during the third year of junior high school. After graduation, students may enroll in vocational schools to accept an additional year of technical training courses combined with a practicum in industries. Although a second year of training is voluntary, the extra training provides better opportunities for students to find a good job.

As mentioned previously, since 2001, the entrance examination of senior high schools was replaced by the Basic Competency Test. Similarly, since 2002, the Joint University

Entrance Examination for college-bound, senior high school students was replaced by the Multi-route Promotion Program. Since then, three alternatives have been available for entrance into colleges or universities, including selection by recommendation, application, or by taking the Joint University Entrance Examination.[15] For selection by recommendation, the student needs a recommendation from the senior high school, and after being recommended, he or she has to take the General Subject Ability Test. However, each school has a quota of recommendations, which means not every student can take advantage of this alternative. Those students who are not recommended by their schools can take the General Subject Ability Test and apply to the departments on their own. The third alternative, for those who cannot get into universities or colleges through recommendation or application, is to pass the General Subject Ability Test and then take the College Testing of Proficiency for Selected Subjects. Based on these scores and students' selection of colleges or universities, the College Entrance Examination Center determines where the student will go.

Suggested Readings

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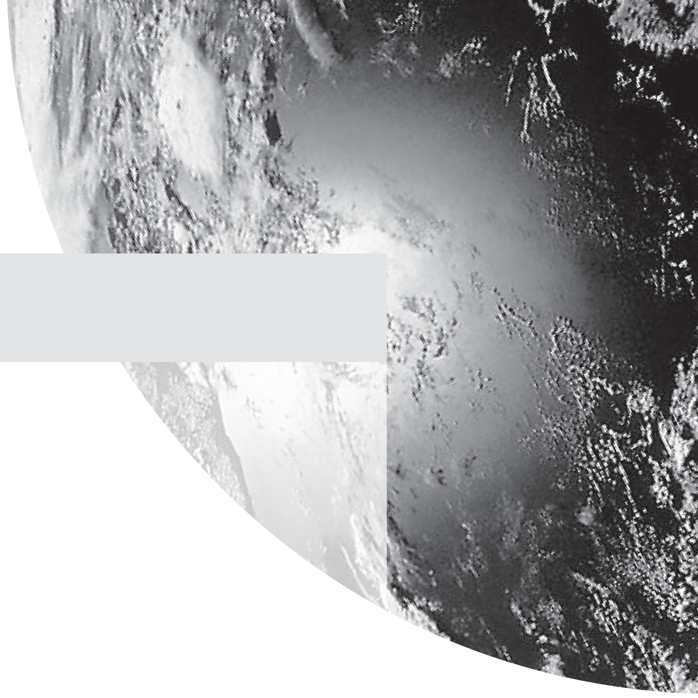

Colombia

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Introduction

Overview of Education System

Colombia's National Constitution[2] guarantees every person the right to access an education and characterizes it as a public service. Furthermore, the General Education Law[3] establishes the principles and goals regulating education in the country. Administering education within the framework established by this law, the Colombian National Ministry of Education is responsible for allocating national resources to operate the public education system. The General Education Law also created the Institutional Educational Projects, making each school responsible for defining and directing its own educational activities. Consequently, departments[4] and municipalities in each territorial division are responsible for providing resources and services for education in their regions.[5]

Within the guidelines established by the Ministry of Education, schools autonomously develop their own curriculum.[6] Formulating curriculum entails organizing the fundamental areas of knowledge for each grade, introducing electives in addition to the subjects established by law, defining methodologies, distributing the time allocated to each subject, and establishing evaluation criteria.[7] However, it is the ministry's responsibility to determine the curricular and pedagogical standards for preschool, primary, and secondary education by creating guidelines and frameworks.[8] The curricular guidelines[9,10,11] offered by the ministry provide a conceptual orientation and Basic Competency Standards[12] aimed at establishing the focus of the curriculum for groups of grades, contributing to the design of the Institutional Educational Projects.

The groups of grades described in the curricular guidelines are K–3, 4–6, 7–9, and 10–11. Education is mandatory for children between the ages of 5 and 15, including 1 year of preschool and 9 years of basic education (5 years of primary school and 4 years of lower secondary school).

Under the General Education Law, both private and public institutions may offer educational services. Presently, 83 percent of schools are public and 17 percent are private.

Language and Population

Under the National Constitution, Spanish is Colombia's official language. However, languages of ethnic groups within the country are official in their own territories. Education is therefore primarily offered in Spanish, but in some regions (such as the original community still rooted in San Andrés and Providencia), education is provided both in Spanish and in the community's first language. For indigenous groups, education is provided in their native languages.

According to the most recent national census in 2005, the country's population was 41.5 million inhabitants.[13] The majority of the population consists of whites and mestizos (those of mixed white and indigenous ancestry). In addition, four other ethnic groups are recognized: the Afro-Anglo-West Indian population, Afro-Colombians (10.6%), indigenous Colombians (3.4%), and gypsies (0.01%). The Afro-Anglo-West Indian population inhabits the archipelago of San Andrés and speaks Creole and English. Indigenous Colombians speak 64 Amerindian languages and are distributed throughout the Amazon jungle, the natural grasslands of the Orinoco region, the Andes, the inter-Andean valleys, and the coastal plains.

Emphasis on Mathematics and Science

In the Colombian education system, the majority of schools have subject area specialist teachers for mathematics and science, mostly starting in the sixth grade. However, in the larger cities, it is common to find specialist teachers, starting in the third grade of primary school.

Although there is no explicit emphasis in mathematics or science, since 2000, education policies have promoted a curricular focus on basic competencies in mathematics, science (natural and social), language, and citizenship. These areas are periodically evaluated by the Colombian Assessment Institute (ICFES), an organization committed to providing elements that will improve education quality in Colombia through evaluation.

Overarching Policies Related to Education and the Curriculum for Mathematics and Science

Since 2002, the national government has been working to create and implement Basic Competency Standards for different mandatory curricular areas, including mathematics and science. The Basic Competency Standards establish clear, common goals, and are intended to guarantee that all schools in the country attain a minimum level of quality.

The Mathematics Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Mathematics Through Eighth Grade

The ministry's guidelines for mathematics can be understood in terms of the following areas: basic knowledge, general processes, and context.

Basic knowledge refers to the specific cognitive processes involved in developing mathematical thinking, including the conceptual and symbolic structures relevant to mathematics. The following topics are considered: numerical thinking and systems, analytical thinking and systems, spatial thinking and geometric systems, metric thinking and measuring systems, and probabilistic thinking and data systems.

General processes refer to the dynamics that support learning. These include reasoning; problem formulation and problem solving; communication through different forms of numerical expression; mathematical modeling; and elaboration, comparison, and execution of specific procedures.

Contexts are situations concerning mathematics, other sciences, the sociocultural environment, and hypothetical situations based upon which the students may think, formulate, discuss, argue, and build knowledge.

Within this framework, standards for groups of grades are established. These standards are described briefly below.

Instruction in **grades 1–3** emphasizes the use of mathematics for formulating and solving concrete problems and applying judgment about the soundness of the solutions proposed. The expectations for students in these grades are presented below.

- *Numeric-analytic thinking*: recognize the meaning of numbers in contexts of measurement, counting, comparison, and location; quantitatively describe situations of change and variation; recognize regularities and patterns; and formulate and solve word problems in additive situations of composition and transformation.
- *Geometric-metric thinking*: describe and produce figures and explore the results from their combination and subdivision; use geometrical diagrams to identify objects in everyday contexts and associate such diagrams with measurement; and master concepts of perpendicularity, parallelism, and symmetry.
- *Data*: classify and organize data and present this information in pictograms and diagrams.

The learning and teaching processes in **grades 4–5** aim to describe the relationship between everyday language and the language of mathematical symbols, so that the student may distinguish between different forms of mathematical representation, such as word problems, formulas, tables, diagrams, and graphs. The expectations for students in these grades are described below.

- *Numeric-analytic thinking*: formulate and solve problems of direct proportionality in the context of multiplication; interpret the meaning of fractions in different contexts involving measurements, differences, quotients, and compare different forms of expressions; and interpret various situations through simple arithmetic equations and inequalities and present them graphically.
- *Geometric-metric thinking*: compare and classify two- and three-dimensional objects according to their properties; visualize the possible results of applying transformations on a plane into two-dimensional objects and move toward an understanding of the concept of congruence; differentiate measurable properties of objects; and use different procedures and strategies for calculating areas and volumes.

- *Data*: present and interpret data in tables, graphs, and diagrams, using information from local sources and simple experiments.

The learning and teaching processes in **grades 6–7** emphasize the identification, description, and representation of concepts and relationships in different situations, as well as their application in solving problems in mathematical and non-mathematical contexts. The expectations for students in these grades are presented below.

- *Numeric-analytic thinking*: use number systems extensively; master equivalent forms for expressing positions in a straight line; understand and apply the properties of operations in different number systems to problem solving; use basic concepts from number theory; and describe and present various situations in arithmetic and geometric contexts.
- *Geometric-metric thinking*: formulate and solve problems involving scale factors and problems requiring estimation techniques; recognize the effects of different transformations; and present and solve problems by applying the basic concepts of proportionality and the geometric properties of congruence and similarity.
- *Data and probabilistic thinking*: describe and present information derived from simple experiments and experiences; obtain and interpret information contained in diagrams and data tables; use measures of central tendency to interpret the behavior of clusters of data; predict and justify reasoning based on statistical information; and use models to make hypotheses about the results of random experiments.

The learning and teaching processes in **grades 8–9** are aimed at promoting a first look at mathematical structures, the use of definitions, the formal methods of argumentation, and valuing mathematics as an instrument for describing situations. The expectations for students in these grades are described below.

- *Numeric-analytic thinking*: compute operations with real numbers; understand the concepts of variables, equations, and inequalities; and apply the concepts to modeling and solving various problems involving linear equations.
- *Geometric-metric thinking*: understand and apply the basic concepts of proportionality and geometric relationships; explore transformations and solve problems through geometric models; and develop procedures to determine measurements.
- *Data and probabilistic thinking*: understand the basic concepts of probability and how they apply to everyday life; calculate the probability of simple events through different methods; identify and interpret information in diagrams and data tables; formulate inferences and arguments based on data analysis; make situation models by designing experiments or situations for determining probabilities; and make predictions based on experimental or theoretical probabilities.

The Science Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Science Through Eighth Grade

The ministry's guidelines for science can be understood in terms of the following issues: basic scientific knowledge, actions and cognitive processes, and knowledge of the real world.

Basic scientific knowledge encompasses interrelated concepts associated with biological, chemical, and physical processes. The student is expected to give a coherent and relevant explanation of different phenomena. For biological processes, the following concepts are included: vital life processes, classification of living organisms, heredity and evolution, and ecosystems. Chemical processes include the atomic structure and properties of matter, chemical changes, and the Earth and its atmosphere. The concepts associated with physical processes include energy, electricity and magnetism, force, light and sound, the Earth and the universe, and various technological developments.

Actions and cognitive processes refers to the actions performed by students in order to learn. These processes include observing, measuring, and manipulating variables; questioning and formulating hypotheses; and making explicit theories. Based on these processes, the student reflects on and revises his or her understanding of scientific phenomenon.

Knowledge of the real world sets a horizon towards which the student's knowledge and misconceptions of the world are modified. It includes a healthy lifestyle and understanding ethical and aesthetic relationships among human beings and these same relationships between human beings and the environment.

It is expected that transformation of the student's understanding through the educational process, fostered by interventions using action and cognitive processes and experiences derived from the real world and scientific principles, will construct meaning at different levels of complexity.

Within this framework, standards for groups of grades are established. These standards are briefly described below.

- **Grades 1–3.** Upon completing the third grade, students should be able to recognize themselves as living beings that share some characteristics with other living things in an environment and understand how the environment in which they live affects them. Students should also develop an appreciation for scientific technology and recognize themselves as agents of change in the environment and in society.
- **Grades 4–5.** Upon completing the fifth grade, students should be able to identify the structures of living things that allow them to adapt to an environment and that can be used as classification criteria. Students also should be able to identify the characteristics of matter, physical phenomena, and energy in the environment, and identify how various environmental changes due to the application of physical, chemical, and biological principles allow for the development of technology.
- **Grades 6–7.** Upon completing the seventh grade, students should be able to identify conditions for change in living things in a balanced ecosystem, establish

relationships between macroscopic and microscopic characteristics of matter and between the physical and chemical properties of the substances that make up matter, and evaluate the potential use of natural resources for technology and the consequences of human use of natural resources.

- **Grades 8–9.** Upon completing the ninth grade, students should be able to explain changes in populations and biological diversity as a consequence of reproduction strategies, genetic change, and natural selection; explain conditions for change and conservation in different ecosystems, taking into account energy transfer and transportation and its interaction with matter; identify how knowledge of heredity and reproduction can improve quality of life; and identify commercial and industrial applications of energy transportation and its interactions with matter.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Time

There are no regulations on the number of hours per week devoted to the areas of mathematics and science because schools are autonomous in determining their curriculum and study plans. Article 23 of the General Education Law establishes that at least 80 percent of the school study plan should be assigned to the curriculum areas deemed fundamental and mandatory. These include: natural sciences and environmental education, social sciences, art education, ethics and values, physical education and sports, religious education, humanities and language, mathematics, technology, and informatics.

Instructional Materials, Equipment, and Laboratories

Schools are given a wide range of autonomy in defining pedagogical strategies and for administering the teaching and didactic resources available. Provision of these resources is decentralized and managed by regional education offices. However, the resources provided must be aligned with the Institutional Educational Project.

Use of Technology

The Ministry of Education has developed a project to be implemented from 2007 to 2010 called *Use and Appropriation of Media and New Technologies*, which works in six major areas.

- The provision of computer technologies and internet connectivity for schools through agreements with the Ministry of Communications and the private sector
- The provision of digital educational resources and contents through the educational portal, *Colombia Aprende*
- The professional development of teachers and administrators
- The development of strategies for technology integration into the curriculum and Educational Institutional Plan

- Support to local education authorities and schools for the use of technology in education
- The evaluation of the project's strategies.

Teachers and Teacher Education

Education and Training for Fourth and Eighth Grade Mathematics and Science Teachers

In order to be qualified as a teacher, several options are available: attending a teacher training program, obtaining an undergraduate degree (*licenciates*), obtaining an undergraduate degree in areas other than education, or obtaining a graduate degree in education (specialization, master's degree, or doctoral degree). Professional programs are offered that allow individuals who are already teachers to obtain the necessary certificates.

According to the law, in order to work as a teacher in the education system and teach at the preschool and basic primary levels, a title from a teacher training college or a certificate verifying someone as an education specialist is a minimum requirement. These teacher training colleges are called Normal Schools. At the secondary level, a college degree in education or a professional title in a related area is required.

Teacher training programs offer preservice education for educators, while college degrees are conferred by education departments through academic programs in the basic and mandatory areas defined in the General Education Law, such as mathematics and science. Undergraduate programs leading to teacher training certificates in basic primary education also are offered with emphasis in a specific area, such as Spanish, mathematics, or science. Universities offer undergraduate degrees, as well as graduate education for advanced training in teaching mathematics and science. Unlike professional degrees in other disciplines, the curriculum in teacher training colleges and college undergraduate programs includes a teaching practicum as a prerequisite for graduation.

Candidates for public school positions are chosen through a merit-based competition conducted by Territorial Educational Secretaries. The competition includes testing, a personal interview, and a profile analysis. Professionals selected in this way who do not have an undergraduate degree in education must be attending or have completed a pedagogy program in a higher education institution by the end of a trial period. This program has been regulated by the ministry[14] and includes a minimum of 480 hours. Private schools do not have to follow these rules.

Due to the location of ethnic groups in some remote regions of the country, there are limitations to guaranteeing that teachers who have studied mathematics and science hold the corresponding teaching positions in secondary schools.

Teacher Professional Development in Mathematics, Science, and Technology

Territorial Educational Secretaries are responsible for creating Teachers' Training Committees to solve priority teachers' educational needs. Universities and some non-governmental organizations are invited to offer on-site teaching training programs, including programs in mathematics and science. These training programs are optional but allow for mobility within the teaching profession. It is expected that the offered training courses contribute to schools' improvement programs. Additionally, in order to promote the creation of good pedagogical practices, the ministry has organized regional forums on learning goals and appropriate teaching methods in areas identified as targets for intervention. The forums include socialization of standards, debates, and teaching workshops.

Examinations and Assessments

National or Regional Examinations

Assessing the quality of basic and secondary education is considered one of the government's strategic policies. To improve educational services, the General Education Law required the creation of the National System of Quality Evaluation under the auspices of the Ministry of Education and in coordination with the Colombian Assessment Institute. The system is responsible for defining criteria and establishing procedures for assessing the quality of teaching, the professional performance of teachers and administrators, student achievement, and the efficacy of pedagogical methods. The system also is responsible for assessing texts and materials, administrative and physical organization of schools, and the overall efficiency in the provision of educational services.

In line with the government's strategic policies, two national assessment programs are being developed: SABER and the state examination for entering higher education. SABER assesses competencies developed during basic primary education (up to fifth grade) and basic secondary education (up to ninth grade) in language, mathematics, science, and civic education. These results provide important information for revising or re-orienting policy and for designing improvement plans in schools. The second program, the state examination for entering higher education, is a set of official and mandatory tests that assess the competencies developed in the mandatory areas of the curriculum, such as mathematics, physics, chemistry, and biology. These tests are administered after completion of upper secondary education (11th grade) and are required for entering a higher education program. In general, higher education institutions consider the examination results to be an indicator of the academic success of candidates. Schools use the results of these tests as input for the design, implementation, and evaluation of improvement plans.

Monitoring Individual Student Progress

For each assessment period, each school autonomously designs a student assessment report form that contains the results of the student's progress in each area of knowledge.

Grade Promotion and Retention Policies

The ministry has introduced policies aimed at controlling student dropout rates and problems associated with grade repetition, for example, automatic promotion, introduced in 1987.[15] Recently, Decree 230[16] established that 95 percent of the total students enrolled in each school should be promoted, and it also restricts grade repetition.

Suggested Readings

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1 The five authors of this chapter are members of the Evaluation of Basic and Secondary Education Group from the Colombian Assessment Institute's (ICFES) Academic Deputy Direction. The following officials and advisors from the National Ministry of Education's Quality Direction also participated in the collection of this information and the revision of drafts: Isabel Fernandes, Héctor Fernández, Laura Barragán, and Fernando Díaz.

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3 Ley General de Educación 115, Congreso de la República (1994).

4 Departments are political divisions equivalent to states.

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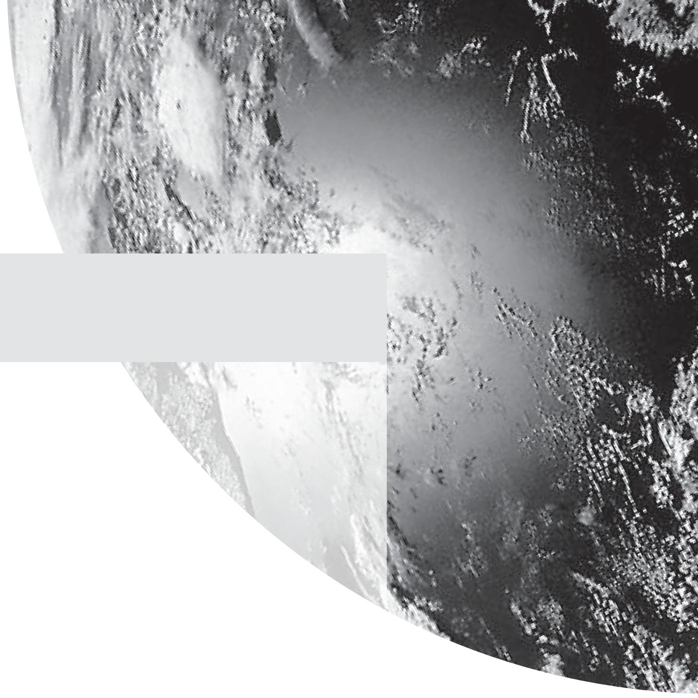

Cyprus

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Introduction

Overview of Education System

The general goal of education in Cyprus is to prepare its citizens through faith in the human values of freedom, democracy, and justice.[1]

The formal education system of Cyprus, up until secondary school, is highly centralized. The Ministry of Education and Culture is responsible for the enforcement of education laws and the preparation of new legislation. The government of Cyprus finances public education, while private schools raise their funds primarily from tuition fees. Therefore, no special funding is provided for mathematics and science. Teachers in public schools are appointed, transferred, promoted, and dismissed by the Educational Service Commission, which is an independent five-member body. The Ministry of Education formulates the intended curriculum for all subjects, including mathematics and science. Syllabi, curricula, and textbooks for all subjects are prescribed to a large extent by governmental agencies.[2]

The education system in Cyprus has three stages: preprimary, primary and secondary education.

Preprimary education in Cyprus, which accepts children beginning at age 3, develops children's wholesome personality in an experiential environment that enables them to recognize their capabilities and enhance their self-image. Attending preschool also helps children achieve smooth and secure transitions into the overall school environment and society. Attending kindergarten is compulsory for all students in Cyprus. Students accepted into kindergarten must be 4 years and 8 months old on September 1 to begin that year.[3] There are three categories of nursery schools—public, communal, and private—which are under the jurisdiction of the Ministry of Education and Culture. Public nursery schools are established by the ministry. Communal nursery schools are established and run by community authorities and parent associations. Private nursery schools are established and run by individuals with the approval of the ministry. Students are not tracked at the preprimary level.

The aim of **primary education** is to create and secure the necessary learning opportunities for children regardless of age, sex, family and social background, and mental abilities. According to the Education Acts for Elementary Education, primary school provides 6 years of compulsory schooling to children once they reach the age of 5 years and 8 months.[4] Officially introduced in 1962, public primary education is free. Schools function in every town or village where there are more than 15 children. Communities with fewer than 15 children are served by neighboring communities.[5] At the end of their 6-year compulsory schooling, primary school graduates receive a leaving certificate. Students are not tracked at the primary level in Cyprus.

Public **secondary education** offers a 6-year program of instruction for children ages 12 to 18. Lower secondary school (*Gymnasium*), which is compulsory, caters to students ages 12 to 15 and offers a broad spectrum of general education. Upper secondary school (*Lyceum*) is open to all students who have successfully completed the *Gymnasium*. Although students are not tracked in secondary education in Cyprus, in the *Lyceum*, students are free to choose a certain specialization and supplementary subjects that go beyond the core subjects.

In addition to the *Lyceum*, students might choose to attend secondary technical and vocational education schools. The vocational stream emphasizes technological subjects, workshop practice, and industrial training, while the technical stream emphasizes academic subjects.

A number of private secondary establishments, ranging from missionary boarding schools to vocationally oriented institutions and foreign language centers, offer education in specialized fields. Although private secondary schools are independent in their operation and curriculum, the majority are registered with the Ministry of Education and Culture and comply with certain curriculum and facility requirements mandated by law.

Language and Population

The population of Cyprus at the end of 2005 was 854,300.[6] At this time, the composition of the population was 76.8 percent Greek Cypriots (including Armenians, Maronites, and Latins), 10.3 percent Turkish Cypriots, and 12.9 percent foreign residents and workers. The official languages of Cyprus are Greek and Turkish, although English is spoken as a foreign language by the vast majority of the population. The language of instruction in all public schools is Greek, although some private institutions use English as a language of instruction.[7]

Emphasis on Mathematics and Science

In Cyprus, there are no special initiatives to encourage students to specifically pursue careers in mathematics or science and technology, since there is no shortage of expertise in these areas.

Due to the country's participation in TIMSS, there have been efforts to change the curriculum to be covered in the elementary school grades. In addition, new textbooks have been developed for mathematics and science at the elementary school level. At the secondary school level, however, no changes have taken place because of TIMSS.

The Mathematics Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Mathematics Through Eighth Grade

The main goals of the mathematics curriculum in primary school are to develop students' mathematical thinking and enable students to identify and solve mathematical problems that are useful to everyday life and the sciences, appreciate the usefulness of mathematics, and enjoy the structured thought and harmony that exists in this subject.[8] The mathematics curriculum covered in the **fourth grade** of elementary school is presented in Exhibit 1.

Exhibit 1 Fourth Grade Mathematics Curriculum in Cyprus

Units	Topics
Whole Numbers	Familiarization Whole number operations Factoring
Fractions	Concepts of fractions Fraction operations (addition and subtraction)
Decimals	Concept of decimals Operations with decimal numbers (addition, subtraction, and rounding)
Measurement	Concepts of measurement (perimeter, area, volume, weight, and time) Metric units Time Currency of the country and its use in everyday life
Geometry	3-D shapes Polygons Angles Lines Circles Symmetries
Statistics	Graphs Probability
Problem Solving	Problem-solving stages Problem-solving strategies

SOURCE: Ministry of Education and Culture. (2007). *School curriculum*. Nicosia: Author.

The mathematics curriculum covered in the **eighth grade** of secondary school is presented in Exhibit 2.

Exhibit 2 Eighth Grade Mathematics Curriculum in Cyprus

Units	Topics
Rational Numbers	Recognition of positive and negative rational numbers Comparisons Absolute values Operations with rational numbers Order of operations Finding arithmetic values of algebraic equations by substitution Problem solving by solution of simple equations
Exponents	Recognition of exponents and their components (with positive indices) Converting the product of equal factors to a power and vice versa Properties of negative exponents Use of negative exponents Recognize and convert numbers into exponential form
Equations and Inequalities	Definitions Recognition of equations and inequalities and their properties Solving equations and inequalities and verification by substitution Algebraic representation of problems Problem solving using equations and inequalities Illustration of inequalities on a number line
Proportion and Ratio	Definitions Simplifying ratios and finding missing quantities Recognition of ratio components and properties of ratio operations Direct and inverse proportions
Surface Area of Two-dimensional Shapes	(Review of seventh grade material)
Solids	Definitions of regular polygons Properties of 3-D shapes (prism, cuboids, cube, pyramid, cylinder, cone, and sphere) Problems involving volume and surface areas of solids

SOURCE: Ministry of Education and Culture. (n.d.). *Mathematics curriculum in lower secondary school*. Nicosia: Author.

The Science Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Science Through Eighth Grade

The main goals of the science curriculum in primary school are for students to develop an inquisitive mind and familiarize themselves with the scientific approach to problem solving, gain scientific knowledge in order to understand themselves and the world around them, and develop attitudes towards the proper appreciation of their environment and become actively involved in preserving and improving it.[9]

The science curriculum that is covered in the **fourth grade** of elementary school is presented in Exhibit 3.

Exhibit 3 Fourth Grade Science Curriculum in Cyprus

Units	Topics
Plants	Trees all year round Forests and their importance Plants of Cyprus Plant taxonomy Taxonomy of leaves
Animals	Vertebrate and invertebrate animals
Human Body	The human skeleton, its function, and its parts Bone creation Protection of bones
Weather, Earth, and Space	Types of soil Ways of land formation
Matter	Air in the atmosphere, the ground, and fresh and salt water Composition of the air
Forces	Factors influencing the balance of objects Simple machines
Light	Transparency in materials Factors that influence the ability to see through transparent materials
Sound	Sound production and transmission Reflection and absorption of sound waves Results of sound waves
Temperature	Physical changes of materials due to heat Study of the phenomena of melting, freezing, boiling, and condensation
Electricity	The importance of electricity Electrical sources Dangers due to electricity

SOURCE: Ministry of Education and Culture. (2007). *School curriculum*. Nicosia: Author.

For example, the physics curriculum covered in the **eighth grade** of secondary school is presented in Exhibit 4. For the sake of brevity, the other science subjects are not described in detail.

Exhibit 4 Eighth Grade Science (Physics) Curriculum in Cyprus

Units	Topics
Introduction	Acquaintance with physics Physical phenomena Concepts and measurements Fundamental measurements and scales Derivative measurements and scales Measurement: mass, time, length, area, volume, and density Size estimation

Exhibit 4 Eighth Grade Science (Physics) Curriculum in Cyprus (Continued)

Units	Topics
Matter and Energy	Particles The atomic model Molecules and atoms The three states of matter and their properties Molecule movement Forms and sources of energy Renewable and nonrenewable sources of energy Energy transformations Conservation of energy
Heat	Temperature Thermal equilibrium Thermodynamic laws Thermal expansion The water freezing phenomenon Melting and breathing Vaporization (boiling and evaporation) and sublimation Heat transfer
Optics	Light as an energy form The mechanics of sight Light traveling in a straight line Diffusion and reflection Plain mirrors Concave and convex mirrors Refraction—Snell's law Spectrum of light Lenses

SOURCE: Ministry of Education and Culture. (2006) *Secondary school science curriculum*. Retrieved May 13, 2007, from http://www.schools.ac.cy/dme/dmecircular/allcircular/ShowAllcircularTablePage.aspx

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Time

The primary school curriculum in Cyprus consists of 35 periods each week and each period is 40 minutes. From the first through the third grades of primary school, students are taught seven periods of mathematics per week. Students from the fourth through the sixth grades of primary school are taught six periods of mathematics per week.[10] In primary school, students in the first and second grades are taught only one period of science per week. Students from the third through the sixth grades of primary school are taught two periods of science per week. However, these numbers are slightly different in schools that have fewer than six teachers.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Through the sixth grade of primary school, there are no specialist teachers in the fields of mathematics and science. Beginning in the seventh grade, specialist teachers are required to have degrees in mathematics or science in order to teach those subjects.

Use of Technology

All secondary and vocational schools and 98 percent of the elementary schools in Cyprus are now equipped with computers. In addition, all upper secondary and vocational schools have Internet connections, while 94 percent of the primary and lower secondary schools do. By the year 2010, however, all classes are expected to be equipped with at least three computers. In primary school, information and communication technology (ICT) is not viewed as a separate subject but as a dynamic means of teaching and learning, reinforcing the curriculum and the development of children's basic skills that are related to concentrating, processing, and presenting information. In the *Gymnasium*, however, ICT is taught as a separate and mandatory subject in grades, 7, 8, and 9.[11]

At the upper secondary level of secondary school, there are usually three or four computer laboratories, and in each laboratory, there are at least 16 computers. In addition, in several *Lyceums*, there are multimedia rooms with four to eight multimedia computers. The teachers of various subjects (e.g., Greek and history) use these computers to demonstrate educational software.

Homework Policies

According to the Ministry of Education and Culture, homework is the basic link between the school and the student's family. Through homework, parents can monitor the work that takes place in class, as well as the degree to which students comprehend materials they have been taught. Homework should be a creative supplement to what takes place in the classroom. It also is essential and enables students to become more independent in terms of their work. Homework assignments should be targeted to the age and the skills of the students; be creative, enjoyable, and of interest to students; reflect the resources that are available to students and their families and not be time consuming; and be able to be completed by the students without the constant assistance of their parents.[12]

Teachers and Teacher Education

Education and Training for Fourth and Eighth Grade Mathematics and Science Teachers

Before 1992, primary and preprimary teacher training was provided solely by the Pedagogical Academy, an institution which offered 3-year degrees. Since the 1992–1993 academic year, the Department of Education at the University of Cyprus has undertaken this role by providing 4-year initial teacher training programs. Since 2007, three additional public universities established on the island also offer 4-year accredited degrees in primary education.

Until 2007, secondary school teachers only needed a university degree in a particular subject in order to be appointed as a public school teacher. Currently, however, considerable effort is being directed to improving the quality of secondary teachers' academic qualifications. For this purpose, since 2007, the University of Cyprus has started organizing a series of courses for all those who wish to become secondary school teachers in public schools. The successful completion of this year-long program is a requirement for being appointed by the Ministry of Education and Culture.

Between 1960 and 1970, there was a shortage of secondary school teachers. By the 1980s, however, due to static enrollment and reduced teacher retirements and the tremendous number of teacher graduates from universities, there has been a large surplus of secondary school teachers in all subject areas, including mathematics and science. There also is an oversupply of primary school teachers due to the increase in the number of universities on the island and, therefore, an increase in the number of accredited teacher education programs.

Teacher Professional Development in Mathematics, Science, and Technology

The Pedagogical Institute serves as a professional development training institution and organizes various teacher professional development courses, some of which are optional. However, successful completion of other courses is a compulsory requirement for teachers who have been promoted to principal or vice principal.

Examinations and Assessments

National or Regional Examinations

Secondary school students have a common high-stakes national examination at the end of secondary school. The Examinations Service of the Department of Higher and Tertiary Education is responsible for the organization and conduct of these examinations. This examination serves two purposes—as a final examination and as an entry requirement for public higher and tertiary education institutes in Cyprus and Greece. More specifically, the entrance examinations are conducted for admission to the University of Cyprus, the Cyprus University of Technology, and public higher and tertiary education institutions of Cyprus, as well as to the higher and tertiary education institutions of Greece. Beginning in 2009, students leaving private secondary school also will have the option of being admitted to the University of Cyprus by submitting their grades on the General Certificate of Education examinations.

Monitoring Individual Student Progress

National examinations or standardized tests are not used to assess primary school students in Cyprus. Oral and written tests and overall class participation, as well as results of work completed at home or in school, are the methods that teachers use to assess students and their progress. Primary school students receive no grades or report cards. However, at the end of primary school, they receive a school-leaving certificate.

Secondary school students are assessed through teacher-made tests, observations, and homework assignments throughout the year, as well as by final school examinations at the end of each academic year. Continuous assessment in the *Gymnasium* is marked on a scale of A–E, supplemented by final examinations in June on a scale of 1–20. Final examinations are administered for the subject areas of Greek, mathematics, history, and natural science. Continuous assessment in the *Lyceum* is on a scale of 1–20 and is supplemented by final examinations in Greek, mathematics, and certain optional subjects. At the secondary school level, students receive grades three times a year in report cards.

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6 This population does not include settlers from Turkey who live in the northern part of the island.

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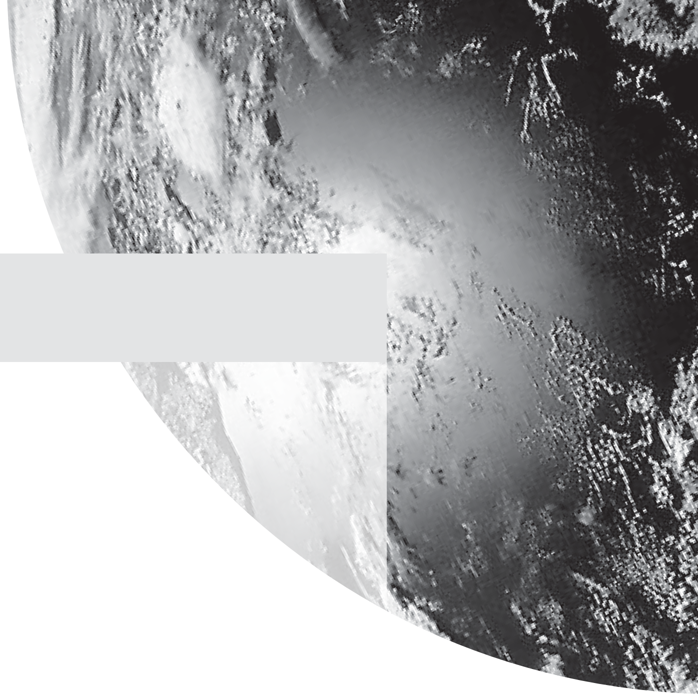

The Czech Republic

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Introduction

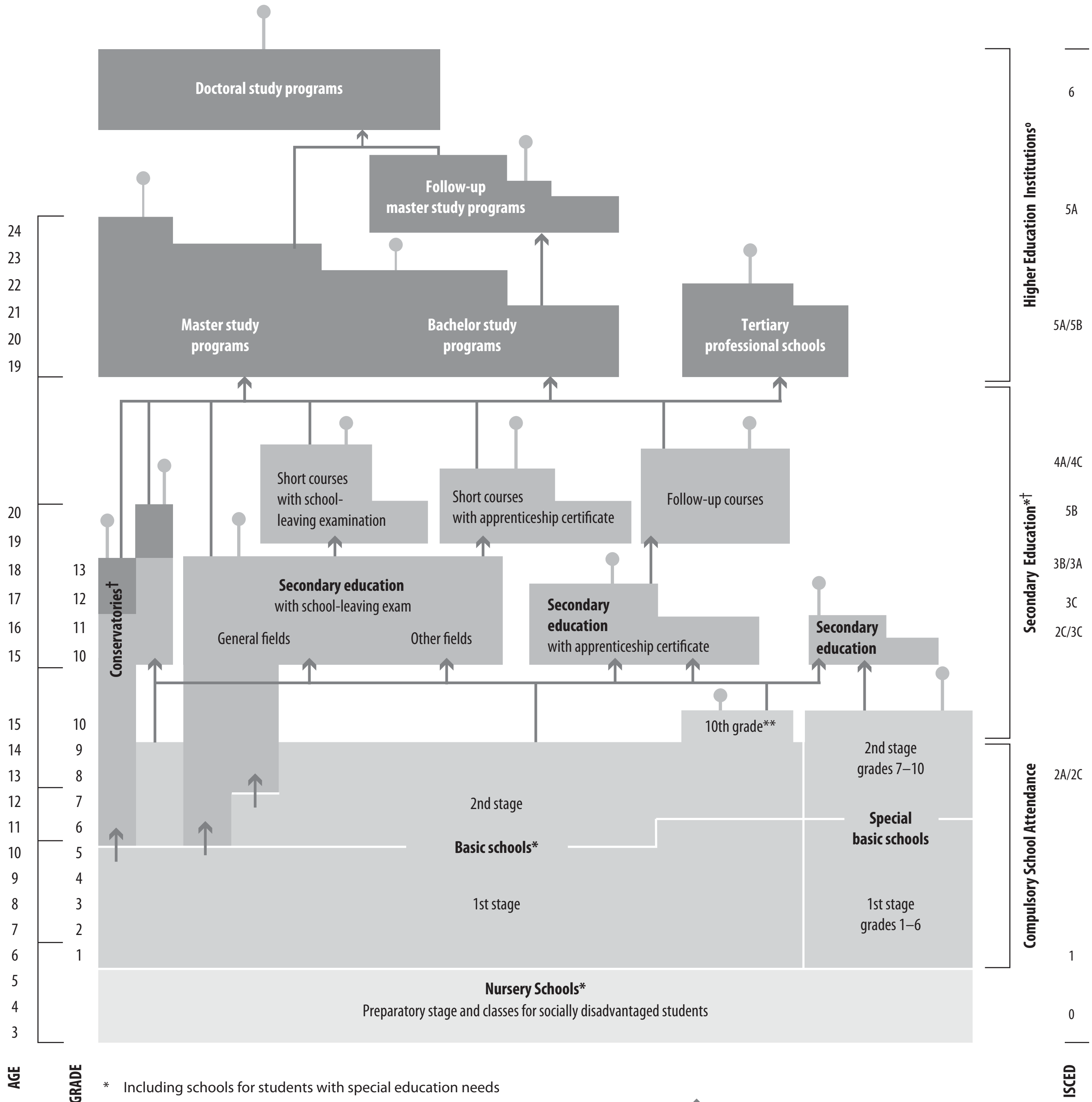
Overview of Education System

Since January 2005, the Czech education system has been operating under two new acts: the 2004 Education Act[2] that regulates education from preprimary to upper secondary schools and the Act on Educational Staff[3] that regulates the teachers of these grades.

The responsibility for schools is distributed among the central government (the Ministry of Education, Youth, and Sport), 14 regional authorities, and municipalities. The ministry[4] is in charge of integrating state educational policy and setting long-term strategies for developing the education system. Regional authorities are responsible for establishing secondary schools and are given a relatively high degree of autonomy. Municipalities establish and administer primary and nursery schools.

Since January 2003, all schools have had the status of legally autonomous entities. The headmaster is responsible for the quality of the educational process, financial management, appointing and dismissing teachers, and relations with the municipality, parents, and the general public. Funding comes from two sources. Capital and running costs are paid from the budget of the regional authority or municipality. Educational costs, such as salaries, are allocated from the state (central) budget by the ministry via regional authorities. Funding is based on the per capita principle.[5] Exhibit 1 shows a summary of the education system in the Czech Republic.

Exhibit 1 Structure of the Education System in the Czech Republic, 2005–2006



* Including schools for students with special education needs
** For students with special education needs
† Students of conservatories can sit for a school-leaving examination also but no sooner than after fourth grade; in the field of dance, after eighth grade.
° Precondition: school-leaving examination

Next educational level
Labor market

SOURCE: Institute for Information on Education. (n.d.). *Education system of the Czech Republic.* Retrieved January 21, 2008, from http://www.uiv.cz/clanek/29/148

Exhibit 2 describes the preprimary, primary, and lower secondary levels of education. Preprimary education includes nursery schools, which are part of the education system.

Although attendance is not compulsory, 95 percent of the age group usually are enrolled in the last preprimary grade.

Education is compulsory in the primary and lower secondary levels. In 1996, compulsory education was extended from eight to nine grades. Thus, school attendance is compulsory for 9 years, usually from ages 6 to 15. All students start at primary school, consisting of the primary stage (grades 1–5) and the lower secondary stage (grades 6–9). During the second stage of primary school, students who meet the entrance requirements can start the multiyear track of general secondary school (the multiyear gymnasium) or conservatory. Thus, general secondary schools provide both 4-year study (upper secondary level) and a 6- or 8-year program (lower secondary and upper secondary). Approximately, 10 percent of students in the appropriate age group study in a multiyear program.

Exhibit 2 Institutions of Preprimary, Primary, and the Lower Secondary Level

Institution	Type of Education	Length	Typical Age	ISCED Level
Mateřská škola	Nursery school	0–3	3–6	0
Základní škola	Primary school	5	first stage: 6–11	1
		4	second stage: 11–15	2A
Gymnázium	General lower secondary	6/8	11/13–19	2A/3A
Konzervatoř	Conservatory lower secondary	8	11–19	2A/3B

There are two prerequisites that need to be fulfilled to be admitted into upper secondary education. Students need to complete compulsory education and satisfy entrance requirements. The content of the entrance examination (written and oral) is determined by individual schools. Exhibit 3 describes the institutions of the upper secondary level.

Exhibit 3 Institutions of Upper Secondary Level

Institution	Type of Education	Length	Typical Age	ISCED Level
Gymnázium	General upper secondary	4	15–19	3A
Střední odborná škola, konzervatoř	Technical upper secondary, conservatory	4	15–19	3A, 3B
Střední odborné učiliště	Vocational upper secondary	3	15–18	3C
		2	15–17	3C
		1–2	15–16/17	2C/3C

The curricular reform of preprimary, primary, and secondary levels is based on gradual implementation of the 2004 Education Act. The main document of the reform is the Framework Educational Program (separate for each educational level and/or track). It represents a central level of the curricular system and defines educational goals and key competencies, as well as educational content. According to the framework, all schools are required to prepare their own School Educational Program. The current reform, started in the 2007–2008 school year, will probably influence achievement results in the future.

Since the 2007–2008 school year, nursery schools have followed their School Educational Program. At the same time, primary schools have started to teach according to this program in first and sixth grades.

The framework for secondary general education was approved in August 2007, and, thereafter, schools will work on their own School Educational Program beginning in September 2009.

Language and Population

The official language is Czech, and, at most schools, it also is the official language of instruction. In the Ostrava region, there are a few schools with Polish as the official language of instruction, since there is a Polish minority in this region.

In the Czech Republic, there are six major population subgroups according to their nationality[6]—the Ukraines, Slovaks, Vietnamese, Russians, Poles, and Germans. Roma people also represent an ethnic minority.

Second-language Instruction

There are some bilingual schools (particularly in Prague) where Czech is the official language of instruction together with one of the following languages—English, German, French, Spanish, or Italian.

Emphasis on Mathematics and Science

Although there is no special national policy aimed at mathematics and science, there are some schools with extended instruction in mathematics and/or science. In addition, there are several nonprofit initiatives focusing on the development of talented students' potential. For example, the Association for Youth, Science, and Technology[7] supports upper secondary students in the fields of biology, chemistry, etc.

The Mathematics Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Mathematics Through Eighth Grade

The mathematics curriculum is set at the national level without any regional specifics. The following summary of the national curriculum represents mathematics education before the current curriculum reform was introduced. As a result, students involved in the TIMSS 2007 assessment were taught according to this curriculum.

Mathematics topics to be covered in the primary level (by the end of fourth grade) are the following.

- *Arithmetic*: whole numbers up to 1,000,000, including comparing and rounding; computation with whole numbers; and problem solving and fractions as parts of a whole.
- *Geometry*: learning shapes in a plane, including triangles, rectangles, squares, and circles; measuring lengths; the perimeter of simple shapes; parallel and perpendicular lines including construction; constructing a rectangle, square, and

circle; finding areas by using a square grid; calculating perimeters and areas of squares and rectangles; problem solving; and learning simple three-dimensional shapes and figures with line symmetry.

Mathematics topics to be covered in the lower secondary level (by the end of eighth grade) are the following.

- *Arithmetic*: whole numbers, including factorization and computations with whole numbers; decimal numbers and computations with decimals; integers and computations with integers; rational numbers and computations with rational numbers; percentages; powers (exponents that are whole numbers only) and square roots; and ratio and direct and inverse proportion.
- *Algebra*: numeric and algebraic expressions; simplifying algebraic expressions; and simple linear equations.
- *Geometry*: angles and the size of angles; line symmetry and central symmetry; triangles and their properties, congruent triangles, perimeters, and areas of triangles; the Pythagorean theorem; quadrilaterals and their properties, perimeters and areas of quadrilaterals; circles, circumferences, and areas of circles; surface areas and volumes of cubes, prisms, and cylinders; construction tasks, drawing triangles and quadrilaterals; and Cartesian coordinates.
- *Statistics*: reading data from and displaying data using tables, bar graphs, and pie charts; and the mean, median, and frequency.

The Science Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Science Through Eighth Grade

The science curriculum is set at the national level without any regional specifics. The main aim of science education is to provide students with useful knowledge for understanding phenomena and processes in nature, everyday life, and technical experiences. At the same time, through learning about various science fields, students should be able to understand natural varieties and be aware of human knowledge value and the need for sustainable life on the Earth.

The following summary of the national curriculum represents science education before the current curriculum reform introduction. As a result, students involved in the TIMSS 2007 assessment were taught according to this curriculum.

- **Science topics to be covered in the primary level** (by the end of fourth grade) are the world around us, landscape, organic and inorganic nature, humans, and healthy nutrition.
- **Science topics to be covered in the lower secondary level** (by the end of eighth grade) are substances and bodies; motion of bodies; mechanical properties of fluids; energy and conversions of various energy forms and their transfer; sound, electromagnetic, and optical phenomena; the universe; measuring of physical quantities; mixtures; the particle composition of substances; chemical reactions; chemical elements, and inorganic compounds; organic compounds; basic life

structure; manifestation of life; the origin and development of life; heredity and mutability; essentials of ecology; viruses, bacteria, and fungi; plant and animal biology; human biology and human health; inorganic nature; exploring nature; the Earth; the natural picture of the Earth; regions of the world and oceans; social and economic environments; landscape and the environment; the Czech Republic; and geographic education, practice, and application.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Time

Both mathematics and science are introduced in the first grade of primary school. At a minimum, mathematics is taught in four lessons (180 minutes) per week in all grades.

Science education begins with the study of the local environment in grades 1–3 and continues with natural science in grades 4–5. The minimal amount of time devoted to science is two lessons (90 minutes) per week. In grades 6–9, science is taught as separate subjects (biology, chemistry, physics, and earth science).

The instructional time may vary among grades. In grades 6–9, physics, biology (including geology), and earth science are taught each in at least one lesson (45 minutes) per week. At least six lessons (270 minutes) throughout grades 6–9 have to be devoted to each of these subjects in total. Between grades 7–9, chemistry is taught in at least four lessons (180 minutes) in total. The actual number of lessons per week in each grade is set by the headmaster.

Instructional Materials, Equipment, and Laboratories

Textbooks and workbooks are widely used in mathematics and science instruction. For each subject (mathematics, biology, etc.), there is a wide range of textbooks. The ministry is responsible for the textbook approval process. Each school may choose approved or not approved textbooks according to the school policy. However, only the approved ones may be purchased using money from the public budget.

Besides textbooks and workbooks, various tutorials, training opportunities, sample lessons on specialized Internet gateways, sample lessons devoted to interactive whiteboard usage, etc., are available to teachers. Such materials usually are prepared by private companies, and some of them are certified by the ministry.

Although instructional materials are widely used, their quality varies a lot among schools. When it comes to the school equipment modernization process, it mostly depends on the financial conditions of each school.

Grade at Which Specialist Teachers for Mathematics and Science Are Introduced

In primary education (grades 1–5), teachers usually are responsible for instruction in all subjects. Beginning in grade 6, there are specialized mathematics and science teachers. Because science is taught as separate subjects, science teachers are specialized in biology, chemistry, physics, and earth science. In general, teachers for the second stage of primary school usually are specialized in two fields (subjects).

Use of Technology

Although learning basic computer skills is part of the curriculum for primary schools, it depends on how well schools are equipped with computers and how much instructional time is devoted to computer skills development. In recent years, the ministry funded a program that provides each school with Internet service.

Students usually build computer skills at school through practical activities in a separate subject usually called "work with information and communication technology." Computers are used rarely in mathematics and science lessons and, if so, it is mainly for illustrative purposes. The new curriculum includes a computer use policy in mathematics and science instruction. However, differences in the computer equipment level of individual schools remains an issue. The ministry has been offering training programs for teachers on how to use computer technologies in their instruction.

The national curriculum contains a statement about the use of calculators for computation with decimals in grade 6 and, in later grades, on the use of calculators to obtain the square, square root, cube, and other exponents of a number. In general, students learn how to use a calculator for solving complex tasks.

Teachers and Teacher Education

Education and Training for Fourth and Eighth Grade Mathematics and Science Teachers

Responsibility for the education of teachers who teach at the first stage of primary school rests solely in the department of education at the universities, with the content and length (4 to 5 years) of study determined by individual departments. According to individual departments and fields of study, a teaching experience lasting from 6 to 12 weeks is required. Graduates are qualified to teach all subjects in the first stage of primary school.

Teachers for the second stage of primary school are trained at departments of education, and the newly accredited study programs are already in place (3-year bachelor's and 2-year master's level). It also is possible to become qualified as a teacher in other departments such as natural sciences or mathematics and physics. Teachers usually are qualified for two subjects. An obligatory teaching experience is at least 4 weeks for one field of study (subject).

Teacher Professional Development in Mathematics, Science, and Technology

The Act on Educational Staff[8] stipulates the professional development of teachers but does not prescribe any particular form. Each headmaster prepares a professional development schedule. Individual preferences, study interests of educational staff members, school needs, and the available budget are factors taken into account.

Professional development is organized by universities, institutions of professional development for teachers, and other organizations. Accreditation of professional development study programs is granted by the ministry, and a certificate usually is issued to a participant. There also is an option of self-study. The ministry stipulates types of professional development and sets the educational staff career schemes (systems).

The recently established National Institute for Further Education[9] has replaced the network of Educational Centers with a main office and 13 regional offices. The primary activity of the institute is to plan and organize educational courses, implement governmental priorities for professional development, and develop national projects supported by the European Social Fund's financial resources. Furthermore, scientific societies, guidance facilities, professional associations (e.g., Czech Mathematicians' and Physicists' Union), and various private organizations also cooperate on professional development activities such as workshops and preparing guidelines.

Examinations and Assessments

National or Regional Examinations

Students in primary and lower secondary educational levels do not take a national or regional examination. When transitioning from primary to secondary school, they have to go through an entrance procedure. Although some schools take into account only student's previous achievement, many schools also require passing an entrance examination. Entrance examinations are prepared by individual schools and usually consist of two parts: the Czech language and mathematics.

Other Tests

The use of standardized tests is not compulsory for schools. However, most schools use some type of commercial test.

Monitoring Individual Student Progress

Students are assessed by teachers on the basis of written work, oral work, and homework (usually on a 5-point scale). The results of continuing assessment are summarized in a report at the end of each semester. Since 2005, verbal assessment is authorized at all educational levels. Meetings with parents are organized to discuss their children's progress. About 96 percent of students successfully complete compulsory education, which includes primary and lower secondary levels.

Grade Promotion and Retention Policies

Students are promoted from one year to the next on the basis of their achievement. If a student fails in the overall assessment at the end of a school year, he or she does not proceed to the next grade. However, students are promoted to the next grade after repeating a year in one stage, as a student can be made to repeat only one grade within the first stage and one within the second stage of primary school.

Based on the request of parents and the school guidance facility, it is possible to transfer an extraordinarily gifted student to a higher grade without attending the previous grade, only if he or she passes examinations that cover the required syllabus of the skipped grade.

The Czech compulsory school attendance has a low rate of failure. For a number of years, the average number of students who have been retained has been 1 percent at the first stage, with the number higher at the second stage.

Suggested Readings

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1 The authors work at the International Research Unit of the Institute for Information on Education (http://www.uiv.cz). Our thanks also go out to other experts who cooperated with us on this chapter.

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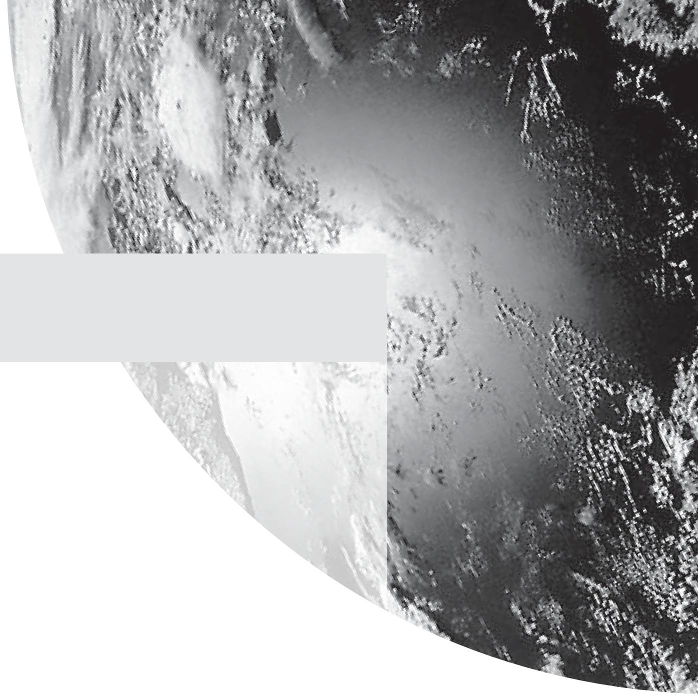

Denmark

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Introduction

Overview of Education System

In Denmark, public primary and lower secondary schools are combined into one school called School for the People (*Folkeskolen*). Although the *Folkeskole* is centrally regulated by the *Folkeskole* Act, it is the responsibility of the individual municipalities to decide how local schools are to function in practice within the framework of the act.

All municipal schools have common goals and provisions for the subjects taught at the different levels, as well as common provisions for the central knowledge and proficiency areas of the subjects and the organization of the school system. However, it is possible to give individual schools a unique focus.

Every school is required to have a school board with representation from parents, teachers, and students. The school board makes recommendations regarding local curriculum, based on the national goals. This local plan is presented to the local authorities and, if approved, made binding for the individual school. The majority of municipalities in Denmark choose to have a common plan for all schools in the municipality.

Public schooling is free in Denmark. Moreover, in order to give everyone equal access to training or education beyond compulsory education, the government offers a monthly grant to students age 18 or older who are enrolled in youth and further education.

The Danish school system is comprehensive in the sense that it includes both primary (grades 1–6), and lower secondary education (grades 7–10), and there is no streaming (i.e., students are not grouped according to ability). When a student enters first grade, he or she meets the classmates with whom he or she normally shares education in all subjects, throughout the 9 or 10 years of school life. The different grades are defined by age groups, and retention is almost nonexistent. The average class size is approximately 20 students.

Basic schooling, grades 1–9, is compulsory. Apart from that, the *Folkeskole* includes a preschool year (kindergarten class) and a 10th year, both of which are optional. Approximately 98 percent of all children attend the voluntary year of preschool.[1] Over

50 percent of students leaving ninth grade attend the optional 10th year, either at the *Folkeskole* or a continuation school.[2,3]

Continuation schools are private boarding schools that emphasize social learning and include subject areas such as sports, music, nature, or ecology. Continuation schools offer schooling from grades 8–10, and some may even offer an 11th year as well. Parents also may choose to send their children to private schools called free elementary schools. These are self-governing institutions required to measure up to the standards of the municipal schools. Free elementary schools and continuation schools receive approximately 85 percent of their funding through state subsidies.

Education is compulsory, but children may be educated in public municipal schools, private schools, or at home, as long as certain standards are met. Of all students, 84.1 percent attend public schools, 12.2 percent attend free elementary schools, 2.9 percent attend continuation schools, and 0.9 percent receive instruction in other educational contexts (e.g., at home).[4]

After compulsory education, a number of different youth education programs are available. These are either academically or vocationally oriented, or both. Today, nearly 80 percent of students each year complete some form of upper secondary education. The government wants to improve this percentage to 95 percent by 2015.[5]

Since 2003, preschool classes have centrally formulated goals within the following areas: language and modes of expression, nature and science, art and music, motor function skills and learning, social skills, and fellowship and collaboration.

Before preschool, most children below the age of 6 are in day care. The municipal authorities are responsible for providing day care for all children from 6 months old until they enter kindergarten. All day care institutions and municipal child minders (i.e., persons who care for children in their home) must present educational plans that include different themes such as social skills and language. The goals of the learning plans are determined by the individual day care. Some municipalities are working on establishing some achievement goals for children visiting kindergartens. Below the age of 1, most children are taken care of at home by one of the parents on maternity leave.[6]

Language and Population

The official language in Denmark is Danish. Like most of the Nordic languages, Danish belongs to the Germanic family of languages. Danish is the language of instruction in public schools and in the majority of private schools as well. A few private schools offer schooling in another language (e.g., English, German, or French).

Since the 1960s, immigration from both Western and non-Western countries has resulted in an increasing number of people in Denmark who speak Danish as a second language. In 2007, immigrants or descendents of immigrants made up 8.8 percent of the Danish population. Immigrants from non-Western countries alone make up 6.1 percent of the population.[7] Foreign-language instruction in schools includes English beginning in third grade and either German or French beginning in seventh grade.

Emphasis on Mathematics and Science

There has been a political emphasis on scientific literacy in the last decade. There is a political and occupational desire to strengthen science subjects by improving not only science skills in general but also increasing the number of students who complete a science education and choose a scientific career. Furthermore, two studies, PISA 2000[8] and PISA 2003,[9] show that Danish students at the age of 15 score below the Organisation for Economic Co-operation and Development (OECD) average in science, which is lower than other countries Denmark usually compares itself to.

In 2005, the Minister of Education, Bertel Haarder, wrote a comment to the *Education Journal*[10] in which he declared that beginning in 2006, the science subjects geography and biology would be evaluated by examinations in grade 9. "The subjects must be given a greater priority and they must be more visible not only in the minds of students and teachers but also in the minds of the parents."[11] Mathematics and physics/chemistry already are assessed in grades 9 and 10 in written and/or oral examinations (in physics and chemistry, only orally). The assessment does not include science at the primary level.

State finances and political programs (e.g., A School in Movement or *En skole i bevægelse*) will ensure continuous development in the scientific subjects in terms of instructional materials, improvement of science laboratories, new cooperation, assessment forms, and will strengthen the professional qualifications of teachers.

Another goal is to improve the connection between science subjects. Schools must clarify lesson plans to secure interaction between the different science subjects through primary and lower secondary school. Furthermore, reports published in 2006[12,13] underline the importance of developing the theory of teaching (subject didactics) in mathematics and especially in science and technology.

Overarching Policies Related to Education and the Curriculum for Mathematics and Science

The current national policies on mathematics and science and technology were published in the 2003 ministerial guidelines, Common Aims (*Fælles Mål*).[14]

As the national curriculum guide, Common Aims establishes binding national goals in the form of centrally defined objectives and intermediate and final achievement goals for each subject, as well as the goals and descriptions of the content of subjects in preschool. Moreover, Common Aims contains the common written, binding guidelines and recommendations for the teaching of every subject for different grade levels.

The introduction of Common Aims in 2003 was a milestone in Danish schools. For the first time, the goals were no longer merely recommendations for the municipalities, but binding national goals for the schools to follow. However, only the goals and not the specific decisions regarding content and teaching materials are centrally defined. Therefore, there are a variety of different school practices around the country.

Mathematics. In Denmark, 10–12 percent of students in the *Folkeskole* have extensive problems in mathematics and need remedial pedagogy. Over 15 percent of students have problems solving more complex mathematics tasks.[15]

Recent research has highlighted some reasons why so many students have problems in mathematics. One reason is the teacher's lack of didactic knowledge. Another problem is the structure of the lessons, which is defined as traditional and organized. Textbooks and common problem solving (e.g., arithmetic and controlling answers) are used. Remedial pedagogy is often based on the same structure by using textbooks one or two grades lower. "Many students do get help, but without a great difference."[16] Other research found that these problems could be based on the fact that only 42 percent of the mathematics teachers from grades 1–4 have mathematics as their main subject in teacher training.[17]

Furthermore, with the introduction of Common Aims in 2003, mathematics instruction poses a much larger challenge for teachers than before. The subject now is defined as being a part of everyday life, and this manifests itself in instruction.

Science and technology. Unlike mathematics, the subject science and technology always has been based on practical methods and exploring working methods. But research indicates the same problems in both subjects: lack of didactic knowledge and a relatively low percentage of teachers who have this subject as their main subject in teacher training.[18] A report written to the government also states that the subject suffers from inadequate professional qualifications.[19]

The Mathematics Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Mathematics Through Eighth Grade

The grade-to-grade structure of the primary school curriculum that covers mathematics instruction is 1–3, 4–6, and 7–9. Thus, mathematics instruction is not individually prescribed for grade 4. The intermediate achievement goals for grade 6 are binding national goals and therefore, they are the guidelines for grade 4 mathematics instruction.[20]

The achievement or end goals for grade 6 in the mathematics curriculum are divided into four categories: numbers and algebra (*Tal og algebra*), geometry (*Arbejde med geometri*), applying mathematics (*Matematik i anvendelse*), and communication and problem solving (*Kommunikation og problemløsning*).

In the category **numbers and algebra**, concrete materials and drawings form the basis for students' continuous work with oral and written mathematical expressions. Calculators and computers are used to develop students' skills in choosing appropriate calculation methods. Decimal numbers and fractions are introduced on a practical level. To increase students' knowledge of diverse academic methods they can choose from, an interaction between the use of language, multiplication tables, graphic representations, and coordinate systems is employed in mathematics instruction.

In the second category, **geometry**, beginning in the lower grades, instruction is based on experiments and studies with geometric forms and patterns. Drawings, geometric programs, and models are used to develop students' academic understanding.

In the third category, **applying mathematics**, academic mathematics problems are based on everyday life, as the students experience it. This approach recognizes the connection between a particular mathematics problem and a mathematics solution (e.g., games are used as a mathematics platform for answering concrete questions about the outcome of the game).

In the fourth category, **communication and problem solving**, mathematics skills and expertise are developed through dialogue. Students evaluate and document mathematics problems and solutions in order to achieve continuous academic development.

The Science Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Science Through Eighth Grade

In preschool, in the subject area nature and science, there are four nationally prescribed achievement goals.[21] These goals concern students' everyday lives, from which they learn to notice different kinds of natural phenomena, ask questions, and discuss their findings. These dialogues are supported by concepts such as categorization, size, number, and weight. Students also will be presented with numbers and patterns of numbers.

The grade-to-grade structure of the primary school curriculum that covers science and technology (*Natur/teknik*) is 1–2, 3–4, and 5–6. Science and technology instruction is not individually prescribed for grade 4. The intermediate achievement goals for grade 4 are binding national goals, and therefore are the guidelines for grade 4 science and technology instruction.[22]

The achievement or end goals for grade 4 in the science and technology curriculum are divided into four categories: the near surroundings (*Den nære omverden*), the distant surroundings (*Den fjerne omverden*), human interaction with nature (*Menneskets samspil med naturen*), and working methods and ways of thinking (*Arbejdsmåder og tankegange*).

The first category, **the near surroundings**, emphasizes connections, differences, and changes (e.g., the characteristics and changes of the local natural surroundings, weather, and seasons). These skills are developed through students' field experiences with nature in their community and appropriate fieldwork and laboratory methods. Learning about the construction and function of the human body and understanding of students' own physical needs also is developed.

Working with psychical, chemical, geographical, and biological elements, students learn about **the distant surroundings**, the second category. To increase knowledge and skills in science and technology, as well as a common scientific interest and curiosity, instruction is based on a comparison of near and distant surroundings.

The third category, **human interaction with nature**, emphasizes the development of students' knowledge about human utilization and the use of nature and techniques (e.g., supported by visits to companies, farms, and museums).

The fourth category, **working methods and ways of thinking**, states that students must learn to explain and communicate simple investigations and also plan and complete simple experiments. Students develop an ability to read and communicate results by organizing and categorizing data.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Time

The Ministry of Education prescribes the minimum hours of instruction in school, but does not decide how many hours are to be spent in each subject topic. The individual teacher is entrusted with the freedom and flexibility to plan and organize instruction.

The total amount of instructional time in grade 4 mathematics is a minimum of 120 hours a year, and for science and technology, 60 hours a year. On a weekly basis, the total amount of instructional time in both mathematics and science and technology is a minimum of 5 hours. One standard lesson is 45 minutes of instruction, but schools may have double lessons or other arrangements.

Instructional Materials, Equipment, and Laboratories

Danish teachers often plan their teaching from a mixed-approach perspective in relation to different materials and interdisciplinarity. Textbooks mostly are used in both subjects, but they are supplemented by materials from students' everyday lives and different kinds of activities (e.g., drama, storyline, and graphic presentations), as well as practical work (e.g., experiments and board and computer games). This approach, as well as outdoor surroundings are used to stimulate interest and wonder about the world of science and develop students' academic language.

Several websites exist that contain ideas for teachers in both subjects (e.g., the Material Platform) through the Danish Education Portal.[23] Also, teachers have created websites, where they describe their projects and lesson plans.[24]

Use of Technology

The use of technology is a priority in the *Folkeskole*. Students are introduced to computers at an early age. Interactive projects and tasks are a natural part of both mathematics and science and technology instruction.

Beginning in 2004 to 2007, individual schools could apply for government funds to purchase computers for grade 3. In 2006, these funds also could be used for equipment such as video projectors and interactive whiteboards.

Teachers and Teacher Education

Education and Training for Fourth and Eighth Grade Mathematics and Science Teachers

In 2007, the teacher education program in the *Folkeskole* was reformed.[25] Education students at university colleges select two or three main subjects from the compulsory subject areas of Danish, mathematics, science and technology, and physics/chemistry. They can decide to choose all main subjects from these areas or select one subject from another area (e.g., a language like German or English). Furthermore, the main subjects Danish and mathematics are subjects that education students can specialize in either at the primary or lower secondary level by selecting them as their first and second main subjects.

Teacher practical training also is assessed (passed or not passed) after each practical training period. If the practical training is not passed, another period of practical training is given.

Teacher Professional Development in Mathematics, Science, and Technology

Teacher professional development is provided at a number of university colleges, where preservice teacher training also takes place. Courses range from stand-alone courses in different subject areas to further education diploma programs. Participation in teacher professional development is voluntary, and a limited number of courses are available. Usually, they are paid for by either the school or the participating teachers themselves.

Examinations and Assessments

National or Regional Examinations

The major changes in Danish school history, from recommended to binding goals and the introduction of national assessments and individual student plans, are in line with the overall focus on quality assurance and evaluation in an internationalized society. In the 2007–2008 school year, the Danish government implemented national compulsory tests in mathematics at grade 6 and at grade 3 (beginning in 2009). At this moment there are no national compulsory tests in science and technology.

In addition to these examinations, at the end of compulsory education, students take formal examinations in up to 10 subjects. Two levels of examination are offered—the Leaving Certificate of the *Folkeskole* (the leaving examination after ninth grade), which is compulsory for all students and the Advanced Leaving Certificate of the *Folkeskole* (the leaving examination after the voluntary 10th grade). The concluding tests in grade 9 are written tests, and they are assessed by censors, one assigned from the ministry and one from the municipality.

These examinations are both written and oral, and standard rules for all examinations ensure uniformity throughout the country. The Ministry of Education develops written examinations, while teachers conduct oral examinations. In addition, a mandatory project assignment gives students in grades 9 and 10 the opportunity to complete and present an interdisciplinary project. The project assignment is assessed in a written statement based on the content, the working process, and the presentation of the final work. The assessment of the project assignment can be indicated in the leaving certificate.

Other Tests

The Ministry of Education composes a standard test in selected subjects for certain class levels. These tests are used as part of the ongoing assessment. The Minister of Education determines the rules for which subjects and class levels the tests should be conducted.[26]

Beginning in 2006, new standard tests have been used in the *Folkeskole*. They are based on information technology, self-scored (local teachers do not mark the tests), provided free to schools, and are adaptive, which means they adapt to the individual student's ability during the testing process (i.e., the student starts with medium-difficulty level items and the test adapts the level of the next items based on the answers to these questions).[27] The mathematics tests are based on the binding national goals described in Common Aims.[28]

There are 10 compulsory tests that will be conducted beginning in 2009.[29]

- Reading (within the framework of the subject Danish) in grades 2, 4, 6, and 8
- Mathematics in grades 3 and 6
- English in grade 7
- Geography, biology, and physics/chemistry in grade 8.

At this point, there are no standard tests in science and technology. However, some forms of assessment are used to monitor students' academic progress in the subject. For example, logbooks are used as a form of academic reflection on topics taught. Questions, reflections, and thoughts are noted in the book, as well as drawings to help younger students with fewer writing skills. Portfolios are used to collect students' own work over a period of time. Pictures of models and experimental setups also are a part of portfolios. Portfolios are discussed as part of student-teacher conversations, or dialogues between teachers and parents.[30]

Monitoring Individual Student Progress

The Folkeskole Act implies that schools are obliged to make current evaluations of students' learning at every grade. The binding intermediate goals, presented in the ministerial framework for the curriculum, are to be evaluated on a regular basis, together with the individual learning goals of the student.

General progress (not grades) in each subject is reported to parents at least twice a year until the seventh year. Beginning in the eighth year, a grade is awarded in subjects that offer a leaving examination. The information is given in writing or (more usually) verbally in a meeting attended by the student, parents, and the teacher. In grades 8–10, the information system is extended to include a written report at least twice a year giving the student's attainment in academic achievement and application. This only applies to the leaving examination subjects.

The Ministry of Education wants to support and further develop a management and evaluation culture based on knowledge of approaches that work. A new website developed in 2007[31] provides teachers with evaluation tools and guidelines in the evaluation process. Compulsory computer-adaptive tests for eighth grade students in reading and science were introduced in the 2006–2007 school year. Moreover, computer-adaptive national assessments related to the intermediate goals were introduced in grades 2, 4, and 6 in the 2007–2008 school year. Students who have dyslexia and use computer-assisted reading programs on a regular basis are allowed to use these in connection with the national assessment tests.

The Ministry of Education also recently introduced the Individual Student Plan. From preschool to grade 10, teachers are now obliged to write individual plans for students, which serve several purposes. The student plans are meant to strengthen the foundation of educational planning and organization, support the current evaluation of individual students, and strengthen collaboration between home and school. The student plan will be at the center of the continuous information sent home about students' progress and is supposed to improve discussions of how parents and schools may support students' educational development.[32]

Suggested Readings

Cito (Testing and Assessment Company): http://www.cito.nl/com_index.htm

Eurydice (The Information Network on Education in Europe): http://www.eurydice.org/

Ministry of Education, Culture, and Science: http://www.minocw.nl/english/

The National Center for Language Education (Expertisecentrum Nederlands): www.taalonderwijs.nl

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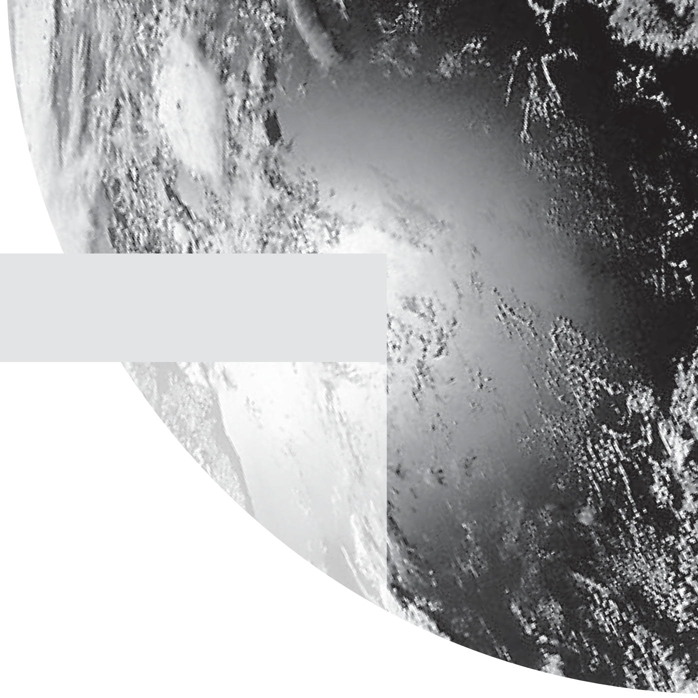

Egypt

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Introduction

Overview of Education System

While the education system in Egypt, especially in the pre-university level, has both centralized and decentralized policies, centralization is the main focus of overall education policy. For example, the *Thanawyya Amma* Examinations (i.e., for grades 11 and 12 of secondary school) are organized nationally, as are promotion examinations, the end of the basic stage examinations, and yearly teacher contracts, which are written by the stakeholders in every educational principalship.

The Minister of Education makes decisions about the education system with the guidance of specific committees and counselors who discuss relevant topics, determine guidelines, and then prepare a report to be reviewed or certified for official release by the minister.

There are three additional agencies that support the work of the ministry: the National Center for Curricula Development, the National Center for Educational Research, and the National Center for Examinations and Educational Evaluation. Each has its own focus, hence, the curricular decisions, especially for mathematics and science, are made by the National Center for Curricula Development, with the help of specific committees at the state level.

The Ministry of Education also is responsible for pre-university education. In collaboration with the civil society and the private and cooperative sectors, the ministry has the responsibility of establishing and managing the educational institutions, which includes active formal, private, and foreign education systems (according to special agreements with foreign educational institutions). Additionally, there is the *Al-Azhar* education system, which has its own institutions, maintains separate facilities for male and female students, and enrolls less than 4 percent of the total Egyptian student enrollment.[1] *Al-Azhar* also has its own features that focus on religious studies. The curriculum is fairly similar to that of the secular system. In both systems, education is free.

Pre-university education is compulsory and consists of two stages. The basic stage includes primary education, which is 6 years, and preparatory education, which is 3 years. Preparatory school offers vocational education. The secondary stage includes 3 years of general secondary education and 3 or 5 years of specific secondary education—commercial, industrial, and agricultural. Preprimary education (kindergarten), which is 2 years for ages 4 to 6, is not compulsory. It prepares children for primary education and its requirements, such as the learning of concepts, skills, values, estimations, etc.[2]

The curriculum and policies for teaching mathematics and science are the same nationwide. There is no special funding for mathematics and science teaching. The government is the main source of funding for education. However, nongovernmental schools—foreign, private, and language schools—have their own funding.

The education system also has newly introduced schools. These are one classroom schools and community schools.

Language and Population

The official language of instruction is the mother tongue of Egyptians, Arabic. English can be used only inside the classroom as a foreign language, and as a result, it is not commonly spoken.[3]

The student population enrolled in the pre-university education system in Egypt is approximately 16 million,[4] not including the *Al-Azhar* education system.

Second-language Instruction

English, French, and/or German can be used in teaching mathematics and science only in language schools and some private schools where instruction in these subjects is presented in the language of the school. In these schools, teachers of mathematics and science are provided with intensive training programs in order to upgrade their level of language use.

Emphasis on Mathematics and Science

There are no special national policies, governmental institutions, or educational initiatives in effect to encourage students to pursue careers in mathematics, science, and technology.

The Mathematics Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Mathematics Through Eighth Grade

The goal with regard to the mathematics curriculum and the teaching of mathematics is to provide students with basic skills in mathematics. Taking into account the potential of students and the balance between what they should learn and be able to do, the focus of the mathematics curriculum is the following.

- Teaching new concepts that rely primarily on using the concepts in new applications for all parts of the curriculum and applying these to the problems of daily life

- Designing lessons for mathematics books, which enable students to find information by themselves
- Providing students with some applications that help them cope with their life and prepare for the future to meet the requirements of the labor market
- Identifying some units of measurement and the relationships between them
- Developing students' problem-solving skills.

Students should acquire many important mathematics skills and attitudes used in life, including the following.

- Reading and writing numbers related to fractions and operations involving these numbers
- Using geometrical tools in the design of geometric shapes
- Using units of measurement and converting from one unit to another
- Using symbols and terminology in reading, writing, and expression in mathematics
- Reading and interpreting quantitative data in various forms
- Understanding basic concepts of geometry and identifying solid figures.

The following is a summary of the national curriculum guidelines for mathematics through **fourth grade** in Egypt.

- Learn about numbers and operations (addition, subtraction, multiplication, and division) and emphasize the value of spatial reasoning and mental mathematics
- Write fractions in different ways, including as percentages, mixed fractions, or decimals
- Use the properties of numbers to simplify operations; use patterns; solve problems; draw to scale; learn about the divisibility by numbers such as 2, 3, 5, etc.; and find different solutions to real-life problems and their applications
- Use number sequences and numerical patterns
- Understand some of the concepts of geometry (a point, a straight line, a ray, a line segment, plane figures, and finding the perimeter and area)
- Learn statistics and probabilities, including collection, organization and presentation of data, representation of data in different ways, and the principles of risk (probability and possibility, etc.).

The mathematics curriculum up to **eighth grade** is as follows.

- Learn operations on integer numbers and the relationship between different sets of numbers
- Study sets, use the language of sets, and learn how to represent sets using Venn diagrams
- Deal with algebraic terms and algebraic expressions and operations

- Solve first-degree equations and the equation of a straight line and resolve issues, such as the application of equations to real life and dealing with numerical patterns.

The Science Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Science Through Eighth Grade

According to the national science curriculum, students should have been taught each of the following topics or skills by the end of **grade 9**.

- What's around us?
- Plants and animals around us
- Tree as a seed
- The human body
- States of matter
- Plants in our life
- Plants in our environment
- Animals in our environment
- The five senses
- Scientific games
- What's in the sky?
- Living organisms' response
- Motherhood in the animal kingdom
- A good meal and its importance for a child's health
- A journey to the moon
- Characteristics of a living organism
- Life on Earth
- Matter around us
- Humans and the universe
- Food and living organisms
- Earth and its atmosphere
- Magnetism
- Structure of a living organism
- Sound and light
- Electricity
- Environment and its resources
- Environmental balance and variety
- Musculoskeletal system

- The effect of some living things on humans and the environment
- Space (planets and stars)
- Nervous system
- Periodic table and chemical reactions
- Electric energy
- Physical phenomena in a human's life
- Reproduction in a living organism
- Human public health.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Time

In mathematics, from first to third grade, students study three periods a week, with each period being 90 minutes (an average of 4.5 hours a week). From fourth to sixth grade, students study six lessons a week, with each lesson being 45 minutes (an average of 4.5 hours a week). From seventh to ninth grade, students study five lessons a week, with each lesson being 45 minutes (3.75 hours a week).

In science, from first to third grade, students study the introduction to science in an activity book. Teaching and learning science begins in fourth grade when students study for 1.5 periods a week, each being 90 minutes (an average of 2.25 hours a week). From fifth to sixth grade, students study three lessons per week, with each lesson being 45 minutes (an average of 2.25 hours a week). From seventh to eighth grade, students study four lessons per week, with each lesson being 45 minutes (an average of 3 hours a week).

Instructional Materials, Equipment, and Laboratories

The following mathematics and science materials, equipment, and laboratories are in use in Egypt through the eighth grade.

- Textbooks, including students' books, activity books, teacher's guides, and workbooks
- Chalkboards, whiteboards, and blackboards
- CDs (for educational and enrichment purposes)
- Pin-me-up posters
- Transparencies, microscopic slides, and positive-charged slides
- Multimedia laboratories
- Traditional science laboratories
- Computer laboratories with Internet access
- Abacuses
- Calculators.

Grade at Which Specialist Teachers for Mathematics and Science Are Introduced

Specialists teach mathematics and science beginning in primary 4.

Use of Technology

Many schools are well equipped with the facilities (technological or traditional) that facilitate teaching and learning. Use of technology differs from one school or governorate to another according to the facilities of the educational principalship. Some schools, called "smart schools", use technology for teaching, where the teacher is a facilitator and the student is a researcher.

Teachers and Teacher Education

Education and Training for Fourth and Eighth Grade Mathematics and Science Teachers

Preparation for teaching requires the completion of preservice[5] courses at universities, which takes 4 years. Mathematics and science comprise 75 percent of teachers' studies and pedagogical studies make up the remaining 25 percent of teacher preparation at universities.

There are no specific requirements to teach mathematics and science. But, in addition to the academic and pedagogical studies, mathematics and science teachers have a practical education course in the third and fourth years at a university to practice real teaching in schools. The number of university graduates who teach mathematics and science in Egypt exceeds the number required for teaching in schools. As a result, there is no shortage of mathematics and science teachers in Egypt.

Teacher Professional Development in Mathematics, Science, and Technology

The central directorate for teacher professional training[6] offers activities to raise mathematics and science teachers' efficiency level. Teachers attend training programs to raise their professional efficiency, recognize modern educational styles through the use of technology, use modern educational multimedia and alternative activities available in the environment, and improve their English language level (for teachers who teach in language schools). Additionally, they receive training on new trends in teaching mathematics and science.

Measures also have been taken to increase the number of qualified teachers and improve the teaching methods of newly appointed teachers through new training programs. Some mathematics and science teachers take part in international professional training programs each year.

Examinations and Assessments

National or Regional Examinations

Promotion examinations[7] in all grades are at the school level except in grades 3, 6, and 9 in basic education (the primary and preparatory stages) and grades 11 and 12 in the secondary stage. For grade 3, the examination is on the district (*edara*) level, while in grades 6 and 9, it is on the governorate level.

For the grade 9 examination, a student's score determines two things: receipt of the Basic Education Certificate and the type of second-level school in which the student will enroll. Only the top scoring students are eligible to matriculate in the general academic secondary schools and then enter a university.

A nationwide examination is administered at the end of grades 11 and 12 for those students in the general academic secondary schools. However, there are no special national and regional assessments specifically in mathematics and science. The score on the nationwide examination determines in which university, as well as in which program, a student can enroll. Because of the high-stakes nature of both these examinations, they are highly competitive. Traditionally, only students attending general academic secondary schools are eligible to matriculate. However, some students from vocational schools have been allowed to enroll since 1970.

Other Tests

Teachers use formative assessment with their students. The Ministry of Education recently implemented an on-going comprehensive assessment in the first three grades of the primary stage where students are able to create their own learning and assessment portfolios.

For the *Adadiya*, sometimes called the Preparatory Certificate, the examination papers are constructed by local inspectors and administered at the level above the *Idara* (i.e., at the governorate level). With respect to the *Thanawiya Amma* (with its two stages, grades 11 and 12), examinations are organized nationally (i.e., set, administered, and marked) by the Ministry of Education. Commercial tests are not used to measure student achievement.

Monitoring Individual Student Progress

According to the Egyptian examination system, both marks and report cards are used to monitor individual student progress. Students receive certificates for each term, with marks allocated for each subject where the minimum and the maximum scores are provided. During the academic year, students receive reports to be signed by their parents in order to follow their children's progress and take any action in case of low achievement reported by teachers and the school administration. Remedial programs are offered under the supervision of the school.

Grade Promotion and Retention Policies

Grade promotion examinations are administered to each student in grades 2, 4, 5, 7, 8, and 10. Proceeding to the next grade is based on scores students obtain in the final examination. Except for grades 11 and 12 (*Thanawiya Amma*), all grades take examinations in two terms (the first term is in January and the second term is in May). In all grades, the second session examination is held if a student fails up to two subjects in the first term. Students are retained if they have to retake examinations for the whole academic year.

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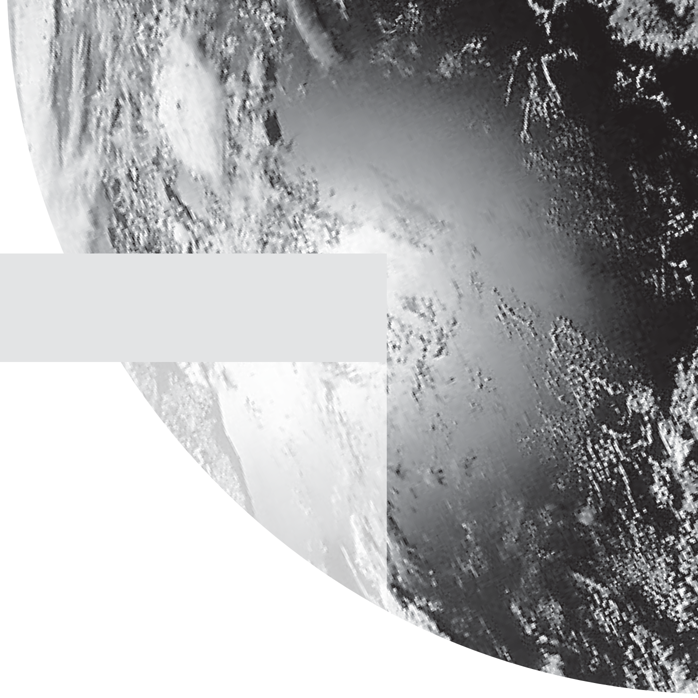

El Salvador

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Introduction

Overview of Education System

The country of El Salvador has made exceptional progress since the end of its Civil War (1992), moving towards a national consensus on the directions to take with its education system. The country has been through a thorough and deliberate process, and the growth in the system has been quite remarkable. Since 1992, preschool, basic education, secondary education, and higher education institutions all have grown rapidly. In fact, at the basic education level, coverage has reached well into the 90 percent range with the opening of hundreds of preschools, providing much greater coverage for many of the rural poor. However, despite this progress, much still needs to be done to ensure that all Salvadorans can obtain an education according to international standards.[1]

El Salvador's National Constitution recognizes that everyone has the right to an education, and the state has a duty to ensure that education is available for all children of compulsory school age and that it is appropriate to their age, abilities, aptitudes, and any special education needs that they might have. To ensure the fulfillment of this right to an education for all its people, the Salvadoran government has organized the Ministry of Education. The ministry is in charge of regulating the whole system of education and is responsible for allocating national resources to operate the public education system. The state also recognizes the right of people and institutions to create private schools, but always within the regulations established by the General Education Law and other guidelines prescribed by the ministry.

Until the early 1990s, the education system of El Salvador was highly centralized. Throughout the rest of that decade, decisions were made and initiatives were implemented that directed the system toward a more decentralized management. Unlike other educational decentralization approaches in Latin America, El Salvador decided not to decentralize through its municipalities, which were thought to have technical limitations and to be at risk for politicization, although they could still collaborate with schools according to their individual capacities. Currently, the education system is decentralized in two ways. First, some of the regulating capacities and resources were transferred from the central offices of the ministry to departmental offices that are located in each of the 14 departments existing in the country. Secondly, the decentralization is based on community participation at the school level. This means that resources and powers are transferred to community associations or education councils that are responsible for the provision of the educational services in every community. The most recognized program in this regard is the Education with Community Participation Program (EDUCO) that began in 1991 and currently covers more than half of the rural enrollment in basic education.[2,3]

Despite the high degree of decentralization achieved in the management of the system, the Salvadoran system of education is mostly centralized in regards to curriculum design. The central office of the ministry prepares and formulates guidelines (*Programas de Estudio*) for each level and grade, and it is within these guidelines that schools and teachers can plan their pedagogic work. These guidelines define the learning objectives and standards, the content of subjects, teaching methodologies, and criteria for evaluating and monitoring student progress. In addition to these guidelines, the central office of the ministry also determines nationwide, for the public schools, the subjects to be taught, the time devoted to each subject, and the textbooks to be used.

Education in El Salvador is divided into formal and nonformal modalities. Although the ministry regulates both, it is mostly in charge of the formal modality. As Exhibit 1 shows, the formal modality is divided into several stages and levels. Basically, El Salvador's education system offers 9 years of basic education, 2 or 3 years of secondary schooling, and several undergraduate options at the tertiary level. Preschool education is not compulsory, but the number of preschools has gradually increased over the last two decades. Tertiary education includes a national university and an increasing number of private universities. While the government provides support to the national university, the cost of a tertiary education is borne primarily by students and/or their parents.

Exhibit 1 Structure of the Education System in El Salvador

Modality	Stage	Level	No. of Years	Age Group	Remarks
Formal	Preprimary	Initial	4	0–4	This is mainly a responsibility of the family.
		K–3	3	4–6	It is free and compulsory.
	Basic Education	First cycle	3	7–9	This stage also is free and compulsory.
		Second cycle	3	10–12	
		Third cycle	3	13–15	
	Secondary Education	Academic	2	16–17	It is oriented toward people whose primary objective is to continue their education at the tertiary level.
		Technical	3	16–18	This is for students whose main purpose is to enter the labor market.
	Tertiary Education			18–23	Only one is a public university.
Nonformal	It includes several flexible options from short-term courses on specific trades to academic programs that allow special students to complete their formal basic and secondary degrees.				

The government of El Salvador has rightly recognized that in order to continue its economic growth and the consolidation of its democratic system, it will need to not only increase and upgrade its human capital but also to change its skill base. Its workforce will need to have sound academic knowledge, technological know-how, and problem-solving skills, which will allow it to be flexible and highly adaptive to new challenges.[4] To meet these challenges, El Salvador already has initiated major reforms of the whole education system that are designed to both substantially increase access and improve the quality of education offered, while ensuring its relevance to a changing, technology-driven economy. El Salvador's government is implementing a Long-term Educational Development Plan (2005–2021) called National Plan of Education 2021.[5] This plan focuses on strategies to improve the quality, access, and relevance of secondary and primary education through three main components: flexible delivery modalities for secondary and primary education (for working and/or rural youth); programs to improve the competitiveness of secondary students; and educational networks (between secondary schools, vocational schools, and universities) linked to a program that strengthens vocational education both at the secondary and college levels while promoting the country's industrial development.[6]

Language and Population

Spanish is the official language of the country, but well-educated people also understand English. Spanish is the language of instruction in schools, except in language schools and some private schools where English is the language of instruction. Although the country was populated by different ethnic groups (especially Nahua-Pipiles in the western and central parts of the country) before the Spaniard colonization, most of the groups have been culturally integrated. In El Salvador, 90 percent of the population is mestizo, 9 percent is White, and only 1 percent is from Amerindian origin.[7]

Emphasis on Mathematics and Science

In the context of the new National Plan of Education 2021 implemented by the ministry since 2004, more emphasis is given to the teaching of science, mathematics, and technology. In terms of policies, the ministry has launched three general policies: technology and connectivity, technical specialization and higher education, and science and technology. Within these policies, four programs are running. The first program, Play to Read, is oriented towards developing basic logic and mathematical skills in children, six years of age. The second, I Understand, is geared towards developing communication and mathematical skills in students who currently are in the third grade of basic education. The purpose of the third program, Get Connected, is to equip public schools with the necessary technology to give students and teachers the opportunity to access new information technologies. The fourth program, Centers of Technical and Technological Education (MEGATEC), will create four technical institutions in the most industrialized areas in the country to promote the study of technical careers.[8]

Also, with the purpose of improving the learning of mathematics, language, and science, the government of El Salvador decided to participate in both the Second Regional

Study of the Quality of Education (SERCE), conducted by UNESCO in Latin America, and TIMSS 2007.

Overarching Policies Related to Education and the Curriculum for Mathematics and Science
The national curriculum of basic education in El Salvador has four core subjects: mathematics, language (Spanish), natural sciences, and social studies. As a result, teachers spend more time teaching these subjects than any other subjects. Since 2004, the ministry has been working on creating and promoting a shift from a general curricular perspective to a focus on the development of basic competencies in all these subjects.[9]

The Mathematics Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Mathematics Through Eighth Grade
According to the national guidelines, basic education (grades 1 to 9) tries to develop in human beings the capacity to understand their own acts and their relations with the world in such a way that they can act for their benefit and the benefit of the community. The first cycle (grades 1 to 3) is instrumental in the sense that it tries to build in children skills that can allow them to understand their own reality and transcend it. The second cycle (grades 4 to 6) builds on that and introduces students to a broader sociocultural reality through a better mastering of language, mathematics, science, and civics skills. In the third cycle (grades 7 to 9), the cultural integration is completed, and students acquire a base of knowledge to continue their education in the tertiary level or to prepare for their entrance into the labor market.[10]

According to the national mathematics curriculum, students should have been taught each of the following topics or skills by the end of **grade 4**.[11]

- **Data and chance**. The general purpose is to initiate students into the habit of collecting, organizing, and representing information that is useful for their lives. Topics include organizing and displaying data using tables, representing in bar graphs information registered in charts, organizing data displays in charts with up to three variables, and interpreting data sets (e.g., draw conclusions).
- **Numbers**. The general purpose is to extend the use of the basic operations (addition, subtraction, multiplication, and division) to larger numbers and introduce the use of decimals and fractions. Topics include reading and writing natural numbers less than a million; ordering natural numbers less than a million; applying the algorithms and properties of addition, subtraction, multiplication, and division of natural numbers; applying the division of natural numbers using two-digit divisors; generating factors of a natural number and using them for decomposing other numbers; comparing fractions, including equivalent fractions and ordering of fractions; and reading and writing decimal numbers.
- **Geometry**. The general purpose is to continue with the process of location and graphical spatial representation and movements in a plane. Topics include locating and reading points in a table; identifying and drawing parallel and perpendicular lines; defining and drawing right, acute, obtuse, straight, and

reflex angles; determining congruency between triangles and quadrilateral figures; classifying quadrilaterals into parallelograms and trapezoids; recognizing polygons and their elements; identifying circles and their elements; and identifying geometric figures and bodies such as a cube, sphere, cone, pyramid, and cylinder.

- **Measures**. The general purpose is to introduce students to the measurement and computation of magnitudes (lengths, areas, volumes, weights, time, and money). Topics include calculating perimeters of polygons; computing the area of triangles; computing the area of rectangles; computing the volume of solids; measuring and estimating weights; calculating and estimating time; and making budgets with simple computations.

There is no specific mathematics curriculum for grade 8, but there are general guidelines for the whole **third cycle** (**grades 7, 8, and 9**) of basic education.[12] According to those guidelines, the third cycle has the following objectives in mathematics.

- Develop logical reasoning through the solution of practical problems
- Understand the basic principles of arithmetic, algebra, geometry, and statistics
- Apply the basic concepts and operations of arithmetic, algebra, geometry, and statistics
- Use mathematics to understand concepts and principles of other disciplines
- Show attitudes of respect, responsibility, and cooperation while working with others
- Show creativity when using mathematical knowledge.

Specific to **eighth grade**, the general objectives also include the following.

- Apply basic notions of statistics when treating information
- Broaden knowledge of numbers and their properties
- Understand the concepts and principles of algebra
- Develop skills to do different types of algebraic operations and computations
- Identify geometric bodies and their properties
- Apply algebraic procedures to the solution of practical problems
- Find creative solutions to problem situations
- Use mathematical language properly
- Show habits and values of order, responsibility, and work discipline
- Acquire skills related to mental estimation and calculation.

In terms of content, by the end of grade 8, students are supposed to be able to do the following.

- Organize and display data using tables, pictographs, bar graphs, pie charts, and line graphs
- Use natural, whole, and rational numbers
- Use real numbers, both irrational and rational
- Be introduced to algebra, notation, and operations
- Operate with algebra: basic operations with monomial and polynomials
- Learn factorization: common factor and trinomials
- Know fractions: least common multiple, algebraic fractions, and complex fractions
- Learn equations: generalities, linear equations, and applications
- Know geometric bodies: cubes, spheres, cylinders, and cones.

The Science Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Science Through Eighth Grade

Science is taught in fourth grade under the subject known as science, health, and environment. Its general purpose is to teach students about the human development processes from a scientific perspective and with concern for human health and a healthy environment. By the end of **grade 4**, students should master the following topics.

- **Characteristics of living organisms**. The general purpose is to recognize the organs and systems of the human body and their functioning, learn about organs and functions of plants, and recognize types of animals by what they eat. Topics include classifying animals according to what they eat, distinguishing vegetables by their stems, leaves, or combinations of these parts, exercising and eating healthy, developing exercises to keep the senses functioning properly, understanding the functioning of the digestive system, understanding the respiratory and circulatory systems, explaining how the human body eliminates waste, analyzing human development during adolescence, and understanding human reproduction.
- **Living a healthy and happy life**. The general purpose is to develop attitudes, habits, and skills that can contribute to the preservation of personal and community health. Topics include identifying food according to its nutritional value, preventing infectious-contagious diseases, constructing school gardens, and learning first aid practices and risk management.
- **Living organisms and their environment**. The general purpose is to learn about the environment and to acquire habits, skills, and values leading to the protection of the environment. Topics include understanding the need of sunlight for the existence of living organisms, learning rational practices to use natural resources, identifying different types of populations and communities and their interaction

with human beings, analyzing problems related to rural and urban living, and understanding the functioning of simple machines that facilitate human labor.

As in mathematics, there is no specific curriculum for grade 8 in science. But there are general guidelines for the teaching of science in the whole **third cycle** (**grades 7, 8, and 9**) of basic education.[13] According to those guidelines, the third cycle has the following objectives in science, health, and environment.

- Obtain a general idea about nature based on immediate perception
- Have a general idea about the natural sciences and their objects of study
- Apply knowledge about nature to personal and social development but with an ecological awareness
- Acquire a scientific attitude through the use of the scientific method in the solution of concrete problems
- Define health and illness as a result of the structural and functional relations of living organisms
- Become acquainted with disorders in nature that lead to human disasters
- Develop skills and habits to prevent human diseases
- Appreciate the place and role of human beings in the conservation of nature
- Foster the scientific perspective through the exercise of observation, objectivity, and honesty
- Promote teamwork and tolerance in other people's opinions about facts.

By the end of **eighth grade**, the students should have accomplished the following objectives.

- Able to provide a basic explanation about movement in nature using concepts such as force, pressure, work, and energy
- Understand how matter changes and transforms itself following natural laws
- Identify the different levels of organization of living organisms
- Define cells as the building blocks of life
- Analyze different mechanisms used by living organisms to survive and adapt to their environment
- Deepen the study of human organisms and the responsibility for keeping healthy in a healthy environment
- Analyze human reproduction and promote responsible sexual behavior.

According to the national guidelines, students also should have been taught each of the following topics or skills by the end of grade 8.

- *Movement in nature*: force, gravity, pressure, energy, sound, light, cause-effect, and human perception
- *Matter*: transformation, combination, conservation, and chemical reactions

- *Living matter*: levels of organization and cells and their functions
- *Common needs in living organisms*: common needs and functions (moving, eating, digesting, coordinating, reproducing, and developing, etc.).

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Time

Both mathematics and science are taught beginning in first grade. However, in the basic education cycle (grades 1 to 9), science is more oriented toward health and environmental issues. Instructional time for mathematics and science at the second basic education cycle (grades 3 to 6) is typically five 50-minute periods per week. The instructional time in each grade at the third cycle (lower secondary) of basic education is shown in Exhibit 2.

Exhibit 2 Weekly Instructional Time in the Third Cycle of Basic Education

Subject	Number of Sessions	Hours	Percentage of Total Time
Mathematics	5	3.75	20
Language	5	3.75	20
Science, health, and environment	5	3.75	20
Social studies	5	3.75	20
Second language	3	2.25	12
Physical exercise	2	1.50	8
Weekly total	**25**	**18.75**	**100**

Source: Ministry of Education. (2002a). *Programas de Estudio de Matemáticas* [Mathematics teaching guide. third cycle of basic education]. *Tercer Ciclo De Educación Básica*. Guatemala: Litografía Van Color S.A.

Instructional Materials, Equipment, and Laboratories

Instructional materials are used to enrich and explain the curriculum. As a developing country, El Salvador does not have enough resources to provide all schools with what they need to achieve quality in education. Inequalities between private and public and rural and urban schools are very apparent in this regard. The Ministry of Education provides free textbooks and materials for all students in the first two cycles of basic education and is working on providing adequate facilities (including laboratories) to all schools.[14]

There are some mandated or recommended materials approved for teaching mathematics and science through eighth grade. The most important are the following.

- *Curriculum for Learning:*[15] a book describing the competence approach in education
- *Assessment to help learning*: guidelines to use for evaluation
- *Subject guidelines (programas de Estudio)*: guidelines to guide the teaching of core subjects

- *Teachers' methodological guides*: material to help a teacher organize his or her tasks
- *Textbooks (grades 1 to 6)*: official textbooks used by students to learn the content of the core subjects
- *Workbooks (grades 1 to 3)*: notebooks with exercises to be developed by students.

Use of Technology

The learning of computer skills is becoming more important in the country and because of that, the government of El Salvador is trying to provide schools with laboratories and multimedia centers and offer training programs for teachers on how to use the new technologies in their instruction. The National Plan of Education 2021 has several projects that are oriented to achieve these ends. Financial resources, however, are scarce.

Teachers and Teacher Education

Education and Training for Fourth and Eighth Grade Mathematics and Science Teachers

Until 1981, preservice training was provided in specialized secondary schools (*Escuelas Normales*). Since that time and through several reforms, the preservice training has been transferred to universities with strong control by the Ministry of Education.

Beginning in 2006, in order to study a university career in education and to become a teacher, a candidate must fulfill the following requirements.

- The candidate must have an intermediate or high level of performance on the Scholastic Aptitude Test administered at the end of high school. If the candidate has a high performance on this test, he or she can enter directly into the pedagogic career of his or her choice. If the candidate only has an intermediate performance, then the performance on the test is added to the student's record in high school. He or she must obtain at least 6.5 points (out of 10).
- Once the candidate has completed all the requirements to obtain his or her undergraduate degree (including all the coursework and professional practice), then he or she must pass the Test of Academic and Pedagogic Competencies.
- When the candidate obtains his or her diploma, then he or she must become certified by the Ministry of Education to enter the labor market.

To receive an undergraduate degree in basic education (to teach grades 1 to 6), the candidate must study 3 years at the university level. Each year is divided into two cycles and to complete each cycle, students need to have between 17 to 22 class hours. The program of studies in the two first cycles of basic education usually is divided in the following way: 33 percent for general, pedagogic, and methodological subjects; 37 percent for core subjects (mathematics, science, etc.); and 30 percent for professional practice.

To teach at the third level of basic education (grades 7 to 9), teachers must have an undergraduate degree with particular emphasis in one of the core areas: language, mathematics, science, or social studies. At this level and at the high school level, however, there usually is a shortage of teachers to teach mathematics and science. To solve this problem, the ministry has created a special program that provides pedagogic training to those who already hold university diplomas in these areas. The program lasts 1 full year and is offered annually.

Despite the reforms of initial teacher training, with its strong emphasis on practice, there are still many teachers with only high degree diplomas who are teaching in a very traditional way. To correct this problem, the ministry has created Centers for Teacher Development for current teachers as part of a new advisory system, along with the efforts of many internationally funded educational reform programs. There has been real hope that significant change in teacher behavior might occur as a result of these efforts.

Examinations and Assessments

National or Regional Examinations

Since the middle of the 1990s, assessing the quality of basic and secondary education has been a top priority for the Ministry of Education. As a result, a National System of Evaluation of Academic Achievement has been created within the ministry. This system is responsible for defining criteria and establishing procedures for assessing students' achievement and investigating the factors that affect it, in both the basic and secondary levels. In both levels, the system uses standardized tests developed by the ministry, with the help of local universities and international consultants.[16]

At the basic level, students have to take a standardized examination at the end of each cycle (at grades 3, 6, and 9). The tests are based on a criterion-referenced perspective and include mostly multiple-choice items from the four core subjects (mathematics, science, language, and social studies). These tests are administered every 3 years to all schools with the main purpose to monitor the performance of students and schools but without consequences attached. Reports are produced for every school with a detailed analysis of the performance of its students in every subject and a general comparison with other schools within the area and at the national level. The report also contains some recommendations for improving performance.

At the end of secondary school, a nationwide examination, Test of Learning and Aptitudes for Students (PAES), is administered. The test is developed and administered by the ministry, with the help of a private university. This test also is based on a criterion-referenced perspective and tries to measure competencies learned by students in the core subjects (mathematics, science, language, and social studies) during secondary school. Students do not have to pass this test, however, the test is 25 percent of the total score they need to obtain their high school certificate. The results of this test also are used by some universities to grant admittance or to place students.

Other Tests

In addition to TIMSS 2007, El Salvador also is participating in the Second Regional Comparative and Explanatory Study that is conducted by the American Laboratory for Assessment of the Quality of Education (SERCE), which measured the academic achievement of students in mathematics, language, and science in grades 3 and 6 in 2007.

Monitoring Individual Student Progress

Since there are no high-stakes tests, teachers and schools monitor the progress of individual students through marks and report cards. Students receive certificates for each term with marks allocated for each subject. Periodically, parents receive school reports of their child's progress to be signed and returned to the school. This allows parents to follow their child's progress and take action when low achievement is reported.

Grade Promotion and Retention Policies

Despite recent improvements, there still are a relatively high number of students in the first three grades that fail to be promoted. At the third cycle of basic education and in secondary education, students who do not pass a class usually get a second chance or get help with remedial classes. If they still fail to get promoted in two or more classes, then they have to repeat the whole year.

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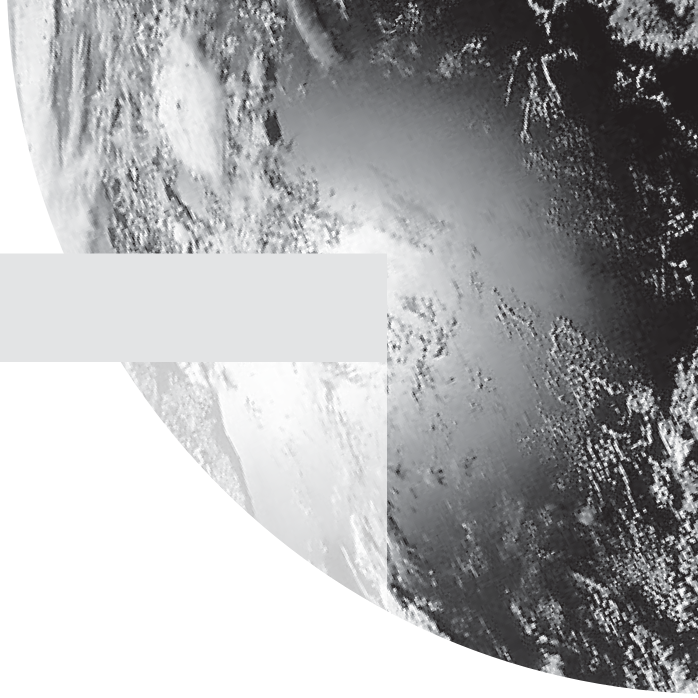

England

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Introduction

Overview of Education System

Approximately 91 percent of students in England attend publicly funded educational institutions.[1] Most of the remaining 9 percent attend privately funded institutions. Education at the school level is administered by the Department for Children, Schools, and Families. At municipal and county levels, local authorities are responsible for organizing state-funded education within their area. Although a great deal of education policy is centrally determined, responsibility for day-to-day decision-making is with the schools. In January 2007, there were 25,000 schools in England, with 8.1 million students enrolled.

The curriculum for mathematics and science is the responsibility of the Qualifications and Curriculum Authority, a government agency. This agency is responsible to the Department for Children, Schools, and Families.

Most primary schools include students from ages 4 or 5 to 11. Thereafter, students move on to secondary school. Most secondary schools include students up to either age 6 or 18. Compulsory schooling starts the school year after the child's fifth birthday and continues to age 16. Publicly funded primary education is nonselective. Most secondary education also is nonselective, with students attending a local school based on parental choice. However, a small number of schools operate some form of selection based on ability or aptitude. Selective schools, which cater to high-ability secondary students, are known as grammar schools. For mathematics teaching, most students in secondary schools are grouped on the basis of ability in mathematics. The same is true of science and some other subjects.

Exhibit 1 shows the structure of the three major phases of the education system: preprimary (up to age 5), primary (ages 5 to 11), and secondary (ages 11 to 16). All publicly funded schools must follow the National Curriculum during the years of compulsory schooling. This curriculum was introduced in 1989 and revised in 1999. In the foreword to the 2000 curriculum, the aim of the curriculum is specified:

> [The National Curriculum] sets out a clear, full and statutory entitlement to learning for all students. It determines the content of what will be taught and sets attainment targets for learning. It also determines how performance will be assessed and reported.[2]

The curriculum for ages 11 to 16 just has been revised, and the new version will be phased in starting in 2008.

Exhibit 1 Structure of the Education System

		Compulsory education	
Phase	**Preprimary**	**Primary**	**Secondary**
Age	Up to age 5	Ages 5 to 11	Ages 11 to 16
Stage	Foundation stage: ages 3–5	Foundation stage: (to end of reception year) Key stage 1: ages 5–7 Key stage 2: ages 7–11	Key stage 3: ages 11–14 Key stage 4: ages 14–16
ISCED	Level 0	Level 1	Levels 2 and 3
Curriculum	Personal, social, and emotional development; communication, language, and literacy; mathematical development; knowledge and understanding of the world; physical development; and creative development.	Core subjects: English, mathematics, and science. Foundation subjects: design and technology, information and communication technology, history, geography, art and design, music, and physical education. Religious education also is taught.	Key stage 3: primary plus a modern foreign language and citizenship. Key stage 4: the three core subjects plus access to design technology, information and communication technology, modern foreign language, physical education, and citizenship.

A wide range of provisions exists for children between the ages of 3 months and 5 years, including child minders (i.e., persons who care for children in homes); day nurseries, preschool groups, and play groups (from ages 2½ to 5); nursery schools or classes (ages 3–5); and reception classes in primary schools (from age 4). Since April 2004, all 3- and 4-year-olds are entitled to free, part-time preschool education in a variety of settings, including preschools and play groups.

In mathematics, a nonstatutory National Numeracy Strategy was introduced in 1998 and formally implemented into primary classrooms in 1999. Introduction into lower secondary classrooms, as the framework for teaching mathematics, followed later. This initiative has strongly influenced how mathematics is taught, particularly in primary schools. The primary framework was changed in 2006 to a more loosely structured model. A science framework was introduced in 2002. Both frameworks are undergoing revision and updating following the launch of the new secondary curriculum in 2007. The teaching of primary mathematics currently is being reviewed with a report expected in June 2008.[3]

Language and Population

In all centrally funded schools in England, the official language and medium of instruction is English. In 2007, 13.5 percent of students in primary schools spoke a language other than

English at home, an increase of 1 percent from the previous year.[4] In secondary schools, the proportion was 10.5 percent. Other predominant languages are those originally from South Asia such as Punjabi, Urdu, Gujarati, Hindi, and Bengali.[5] The official policy is that children who are at the earliest stages of learning English should be integrated into mainstream schools, with additional language support if necessary.

The Mathematics Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Mathematics Through Eighth Grade

The current mathematics curriculum dates from 1999 (but is based on the original curriculum first introduced in 1988) and is structured in key stages which are age related. Key stage 1 is years 1 and 2 of primary school, ages 5 to 7. Key stage 2 is years 3 to 6 of primary school, ages 7 to 11. Key stage 3 is years 7 to 9 of secondary school, ages: 11–14. (Only key stages 2 and 3 will be described since those are the grades tested in TIMSS.) The content is divided into four attainment targets, but there are variations between the targets in each of the key stages. Attainment targets apply to all key stages unless indicated otherwise. Attainment target 1 includes using and applying mathematics. Attainment target 2 includes number for key stages 1 and 2 and number and algebra for key stage 3. Attainment target 3 includes shapes, space, and measures. Attainment target 4 includes handling data for key stages 2 and 3. A series of levels of performance are defined, and the expected relationship between these levels of performance and the key stages are shown in Exhibit 2.

Exhibit 2 Levels of Performance and Expected Attainment

Range of Levels Within Which the Majority of Students Are Expected to Work		Expected Attainment for the Majority of Students at the End of the Key Stage	
Key stage 1	1–3	At age 7	2
Key stage 2	2–5	At age 11	4
Key stage 3	3–7	At age 14	5 or 6

The main content areas for **key stage 2** are listed below. The four attainment targets are listed first, in italics, and the main content areas for each attainment target are listed after the colon.

- *Using and applying mathematics*: problem solving, communicating, and reasoning.
- *Number:* numbers and the number system, including counting, number patterns and sequences, integers, fractions, percentages and ratios, and decimals; mental, written, and calculator methods of calculations, including number operations and the relationships between them; and solving numerical problems.
- *Shapes, space, and measures*: understanding properties of shapes, positions, movement, and measures.
- *Handling data:* processing, representing, and interpreting data.

The following is an example of one of the levels of performance, **level 4**. This is the level most 11 year olds are expected to achieve by the end of key stage 2. This example also describes the performance level of many of the students who took the TIMSS grade 4 mathematics assessment a year earlier. The examples are for the first two of the four attainment targets.

- **Attainment target 1, using and applying mathematics.** Students are developing their own strategies for solving problems and are using these strategies both in working within mathematics and applying mathematics to practical contexts. They present information and results in a clear and organized way. They search for a solution by trying out ideas of their own.
- **Attainment target 2, number and algebra**. Students use their understanding of place value to multiply and divide whole numbers by 10 or 100. In solving number problems, students use a range of mental methods of computation with the four operations, including mental recall of multiplication facts up to 10 times 10 and quick derivation of corresponding division facts. They use efficient written methods of addition and subtraction and short multiplication and division. They add and subtract decimals to two places and order decimals to three places. In solving problems with or without a calculator, students check the reasonableness of their results by referring to their knowledge of the context or the size of the numbers. They recognize approximate proportions of a whole and use simple fractions and percentages to describe these. Students recognize and describe number patterns and relationships, including multiples, factors, and squares. They begin to use simple formulas expressed in words. Students use and interpret coordinates in the first quadrant.

The main content areas for **key stage 3** are listed below. The four attainment targets are listed first, in italics, and the main content areas for each attainment target are listed after the colon.

- *Using and applying mathematics*: problem solving, communicating, and reasoning.
- *Number and algebra*: numbers and the number system, including integers, powers and roots, fractions, decimals, percentages, and ratios and proportions; mental, written, and calculator methods of calculations, including number operations and relationships between them; solving numerical problems; equations, formulas, and identities, including the use of symbols, index notation, equations, linear equations, formulas, direct proportion, simultaneous linear equations, inequalities, and numerical methods; sequences, functions, graphs, and gradients.
- *Shapes, space, and measures*: geometrical reasoning, including angles and properties of triangles, other rectilinear shapes, circles, and 3-D shapes; specifying transformations and coordinates and properties of transformations; measures, construction, and measurement.
- *Handling data*: specifying the problem and planning, collecting data, processing and representing data, and interpreting and discussing results.

The curriculum gives particular emphasis to attainment target 1, using and applying mathematics, by relating the other three attainment targets to it. The curriculum described above was the one in use when the TIMSS 2007 assessment was administered in England. There has been a review of the curriculum for key stage 3, and a new curriculum has been published. This new curriculum will be introduced to Year 7 students in the fall of 2008. The organization of the content is different, with an importance statement and sections on key concepts, key processes, range and content, and curriculum opportunities. Each of these has explanatory notes. There continues to be four attainment targets: mathematical processes and applications, number and algebra, geometry and measures, and handling data. Each attainment target has level descriptions.

The Science Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Science Through Eighth Grade

The science curriculum also dates back to 1999 and is structured in key stages in the same way as the mathematics curriculum. There are four attainment targets, and these apply to each of key stages (1, 2, and 3): attainment target 1, scientific inquiry; attainment target 2, life processes and living things; attainment target 3, materials and their properties; and attainment target 4, physical processes.

The main content areas for **key stage 2** are listed below. The four attainment targets are listed first, in italics, and the main content areas for each attainment target are listed after the colon.

- *Scientific inquiry*: ideas and evidence in science and investigative skills, including planning, obtaining, presenting, considering, and evaluating evidence.
- *Life processes and living things*: life processes; humans and other animals, including nutrition, circulation, movement, growth and reproduction, and health; green plants, including growth, nutrition, and reproduction; variation and classification; living things in their environment, including adaptation, feeding relationships, and micro-organisms.
- *Materials and their properties*: grouping and classifying materials, changing materials, and separating mixtures of materials.
- *Physical processes*: electricity such as simple circuits; forces and motion including types of force; light and sound, including everyday effects of light, seeing, vibration, and sound; the Earth and beyond, including the sun, Earth, moon, and periodic changes.

The following is an example of one of the levels of performance, **level 4**. This is the level most 11 year olds are expected to achieve by the end of key stage 2. This example describes the performance level of many of the students who took the TIMSS grade 4 science assessment a year earlier. The examples are for the first two of the four attainment targets.

- **Attainment target 1, scientific inquiry.** Students recognize that scientific ideas are based on evidence. In their own investigative work, they decide on an appropriate approach (e.g., using a fair test) to answer the question. Where appropriate, they describe or show, in the way they perform their task, how to vary one factor while keeping others the same. Where appropriate, they make predictions. They select information from sources provided to them. They select suitable equipment and make a series of observations and measurements that are adequate for the task. They record their observations, comparisons, and measurements using tables and bar charts. They begin to plot points to form simple graphs and use these graphs to point out and interpret patterns in their data. They begin to relate their conclusions to these patterns and to scientific knowledge and understanding and communicate them with the appropriate scientific language. They suggest improvements in their work, giving reasons for their suggestions.
- **Attainment target 2, life processes and living things**. Students demonstrate knowledge and understanding of life processes and living things drawn from key stage 2 or key stage 3 program of study. They use scientific names for some major organs of body systems (e.g., the heart at key stage 2 and the stomach at key stage 3) and identify the position of these organs in the human body. They identify organs (e.g., stamen at key stage 2 and stigma and root hairs at key stage 3) of different plants they observe. They use information based on observable external features to help them identify and group living things systematically. They recognize that feeding relationships exist between plants and animals in a habitat and describe these relationships using food chains and terms (e.g., predator and prey).

The main content areas for **key stage 3** are listed below. The four attainment targets are listed first, in italics, and the main content areas for each attainment target are listed after the colon.

- *Scientific inquiry*: ideas and evidence in science and investigative skills, including planning, obtaining, presenting, considering, and evaluating evidence.
- *Life processes and living things*: cells and cell functions; humans as organisms, including nutrition, movement, reproduction, breathing, respiration, and health; green plants as organisms, including nutrition, growth, and respiration; variation, classification, and inheritance; living things in their environment, including adaptation, competition, and feeding relationships.
- *Materials and their properties*: classifying materials, including solids, liquids, and gases and elements, compounds, and mixtures; changing materials, including physical changes, geological changes, and chemical reactions; patterns of behavior in metals, acids, and bases.
- *Physical processes*: electricity and magnetism, including circuits, magnetic fields, and electromagnets; forces and motion, including force and linear motion, force and rotation, and force and pressure; light and sound, including the behavior of

light, hearing, vibration, and sound; the Earth and beyond, including the solar system; energy resources and energy transfer, including conservation of energy.

The curriculum gives particular emphasis to attainment target 1, scientific inquiry, by relating the other three attainment targets to it. The curriculum described above was the one in use when the TIMSS 2007 assessment was administered in England. There has been a review of the curriculum for key stage 3, and a new curriculum has been published. This new curriculum will be introduced to Year 7 students in the fall of 2008. The organization of the content is different, with an importance statement and sections on key concepts, key processes, range and content, and curriculum opportunities. Each of these has explanatory notes. There continues to be four attainment targets: how science works; organisms, their behavior, and the environment; materials, their properties, and the Earth; and energy, forces, and space. Each attainment target has level descriptions.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Time

The amount of time allocated to each curriculum subject is not prescribed. At the primary level, the typical school week is 23 hours and 30 minutes, of which about 20 percent is likely to be devoted to mathematics and 10 percent to science. At the secondary level, the school week is usually 25 hours, with typical proportions of 12 percent for mathematics and 10 to 15 percent for science.

Instructional Materials, Equipment, and Laboratories

There are no centrally published or mandated books for teaching mathematics or science. Materials provided by the National Strategies for mathematics and science have influenced classroom practice.

Use of Technology

There has been considerable investment in the use of information and communication technology (ICT) in schools. A review by the British Educational Communications and Technology Agency in 2006 revealed that there had been a considerable increase in the use of ICT in primary schools from 2002 to 2005, with a focus on materials for teaching literacy and numeracy.[6] For the most part, this was related to a large increase in the availability of interactive whiteboards. By 2005, 69 percent of primary school subject leaders who were surveyed indicated that interactive whiteboards were used in at least half of all lessons. In 2002, the equivalent figure was 6 percent. Secondary schools have large numbers of computers available. Calculator use is part of the requirements of the National Curriculum.

Homework Policies

There are no official policies on mathematics and science homework at either grade 4 or grade 8. For grade 8, homework is widely given in both subjects.

Teachers and Teacher Education

Education and Training for Fourth and Eighth Grade Mathematics and Science Teachers

In January 2007, there were 439,200 full-time teachers in schools in England.[7] Teaching is an all-graduate profession into which there are three routes. Prospective teachers must have gained two or more advanced levels (or equivalent) prior to acceptance into a training course and have passed five or more subjects with a grade of C or higher in the General Certificate in Secondary Education, including English and mathematics. This is most commonly taken at age 16 and advanced levels at age 18.

Prospective teachers may undertake a 3- or 4-year degree that combines the study of one or more academic subjects with professional training in aspects of education (Bachelor of Education or Bachelor of Arts, with a recommendation for a qualified teacher status). Alternatively, a 3-year bachelor's degree can be followed by a 1-year postgraduate Certificate in Education. The third, least common way of attaining qualified teacher status, is an employment-based route. The majority of teachers entering secondary schools have a relevant degree and a postgraduate Certificate in Education. First degrees that confer qualified teacher status are more common among primary teachers.

The content of initial teacher education programs is, in part, determined by the rigorous demands of a series of professional competencies that student teachers must attain. These are organized into three interrelated categories: professional values and practice, knowledge and understanding, and teaching. Prospective teachers also must pass skill tests in literacy, numeracy, and information and communication technology.

Student teachers are registered with higher education institutions and spend a large proportion of their time in the classroom under the supervision of a practicing teacher. Primary teachers are trained to teach all subjects in the National Curriculum, while secondary teachers are subject specialists.

During the early part of their teaching career, newly qualified teachers are supported by a mentor within their school, and qualified teacher status is confirmed on satisfactory completion of three school terms of teaching (the induction year). This is intended to provide a bridge between initial teacher education and effective professional practice.

Teacher Professional Development in Mathematics, Science, and Technology

There are a variety of opportunities for continuing professional development for teachers. These range from short, one-day courses to higher degrees, studied part-time over several years. Professional development may be provided by individual local authorities, higher education institutions, or specialist companies or consultants. All schools have 5 days in each academic year allocated to professional development. The specific days and subjects are decided by the school.

The National Centre for Excellence in Teaching Mathematics and the National Network of Science Learning Centres have been set up to provide ongoing support for teacher professional development.

Examinations and Assessments

National or Regional Examinations

There is an extensive structure of formal assessment in England, beginning with a mandatory teacher assessment of 5 year olds in funded settings at the end of the Foundation Stage. Assessments are mandatory at the end of each key stage (ages 7, 11, and 14). Children are assessed in English (reading, writing, and spelling) and mathematics at ages 7, 11, and 14. Science is included at ages 11 and 14. At age 7, the assessments are made by the teacher, informed by the outcomes of a series of formal tests. At ages 11 and 14, all mandatory assessments are through formal paper and pencil tests. In mathematics, there also is a mental mathematics test administered via compact disk. In both science and mathematics, two written tests are taken. In mathematics, one test is taken without the use of a calculator and one with a calculator. New tests are developed each year. At age 11, the tests address levels 3–5 of the National Curriculum. At age 14, levels 3 to 7 are assessed in science, while for mathematics, level 8 also is assessed. There are two difficulty levels (tiers) available in science Levels 3 to 6, and 5 to 7, and four in mathematics, levels 3 to 5, 4 to 6, 5 to 7, and 6 to 8. Students are awarded the national curriculum level of attainment according to the number of marks scored. There is a pilot of a series of shorter tests in mathematics that may replace the system described above. These tests are taken when the teacher judges the student is ready, rather than at the end of the key stage.

The tests for children ages 11 and 14 are scored externally by trained scorers, and the results are returned to schools. These results are published nationally on a school-by-school basis. This has contributed to the tests' high profile in England. The results for 7 year olds are published at a national summary level. These results contribute to the measures of school effectiveness known as "value-added measures". These are intended to measure the progress made by students from the end of one key stage to the end of another, in comparison with students of the same or similar prior attainment.[8]

At age 16, secondary school students participate in a variety of vocational and nonvocational examinations. There are national targets for the percentage of students who attain these awards. Students take advanced level examinations in three or four subjects at the age of 18, after 2 years of postcompulsory education. Examination results are published for individual schools for students ages 16 and 18.

Other Tests

A wide variety of additional test materials, including standardized tests, are available from commercial publishers. Some schools elect to use these to supplement information from the mandatory tests. In addition, national optional tests in mathematics are available and widely used for students in years 3, 4, 5, 7, and 8. The government collects statistics that give insight into the progress of schools, cohorts, and individuals over the course of their school careers.

Monitoring Individual Student Progress

Teachers are required to make assessments of students' attainment using the National Curriculum level descriptions at the end of each key stage. Attention is being given to assessments for learning or formative assessment, rather than a focus on the summative, end-of-key-stage assessments related to national education targets and performance league tables. Teacher assessment levels are reported to parents alongside mandatory test results at the end of each key stage. Teachers can elect to use centrally produced optional tests in mathematics as a means of collecting further evidence to support their own assessments.

A substantial pilot initiative recently has begun in 10 local authorities using individual student-level data, based on an overview of assessments for learning outcomes, to closely track the progress of students. Students then are offered externally marked tests, available every 6 months, when they are ready to take the next level.

Suggested Readings

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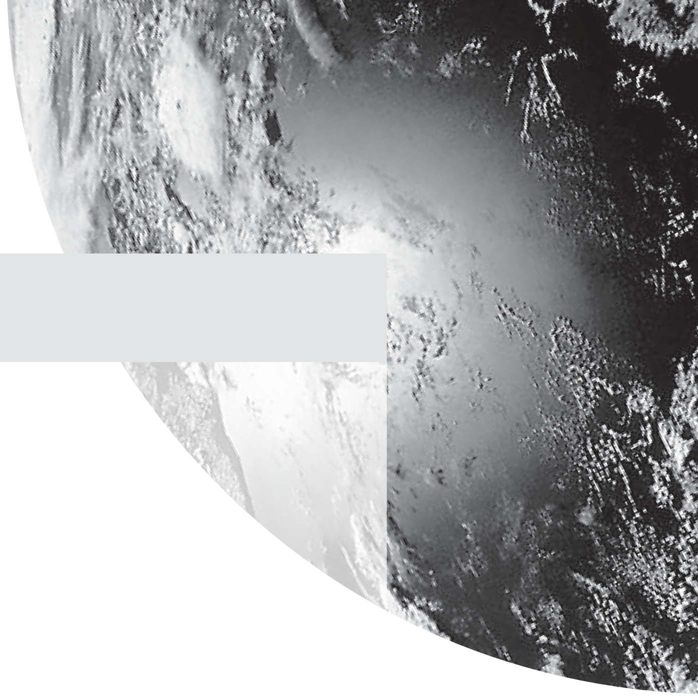

Georgia

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Introduction

Overview of Education System

The Parliament of Georgia determines the fundamental direction of the education policy in Georgia and develops and approves all legal acts concerning the general education system. The Georgian government implements policy in the field of general education, determines the amount of financing, and, together with the parliament, approves the national targets of general education. The Ministry of Education and Science implements the state policy in the field of general education and approves the national curriculum, professional standards for teachers, and the criteria for evaluating textbooks. It also compiles statistical information about schools, approves criteria for the accreditation of the systems of general education and education programs for the professional development of teachers, establishes schools, issues licenses for private schools, and determines the minimum salaries for teachers.

In 2005, the Parliament of Georgia adopted the Law on General Education. According to this law, general education is financed through a voucher (per capita) system. In this system, funds are given to schools in accordance with the number of students enrolled and its geographical location. The school administration and board of guardians, which consists of equal numbers of democratically elected teachers and parents and one high school student, determine how this budget will be spent.

The Ministry of Education and Science[1] carries out the state policy with the aid of the following subsidiary organizations.

- The Teacher Professional Development Center[2] is responsible for teachers' professional development standards, carries out teachers' certification, and develops accreditation criteria for teachers' training and professional development courses.
- The National Education Accreditation Center[3] carries out the accreditation of educational organizations and various professional courses.

- The National Examination Center[4] carries out entrance examinations for various stages at the higher education institutions, as well as international assessments.
- The National Curriculum and Assessment Center[5] creates and develops the national curriculum, ensures the consistency of textbooks with quality criteria, and carries out the assessment of student achievement nationally.

The general education system has three levels: elementary education (grades 1–6), lower secondary education (grades 7–9), and upper secondary education (grades 10–12). Students enroll in school at age 6, with no preliminary competency level required for enrollment.

The general education system of Georgia includes 2,284 state and 257 private schools. In nearly 500 Georgian schools, instruction is in the minority languages of Russian, Azerbaijanian, or Armenian. There are approximately 150 Russian, 150 Armenian, and 150 Azeri schools in Georgia. Ossetian schools provide instruction in Ossetian in the first four classes, and then instruction is in Russian.

Currently, there are approximately 600,000 students enrolled in Georgia. Students are not assigned to classes according to their ability. The national curriculum prohibits division of students according to their strengths or weaknesses. Teachers decide what teaching strategies to use and create syllabi that meet the requirements of the national curriculum. As of 2005, the national curriculum mandates that class size should not exceed 30 students in elementary classes. However, class size differs dramatically between rural schools in the high mountains and urban schools.

State curriculum is not available in **pre-elementary** education in Georgia. Preschool education organizations are nurseries and kindergartens (both governmental and private), which are attended by 25–50 percent of children.

At the **elementary** level, the main subjects include native language and literature, Georgian as a second language (for minority students), mathematics, natural sciences, foreign language, art, music, and physical culture. Social sciences are taught beginning in the fifth grade. At this level, students learn subjects in an integrated way (e.g., science is taught as a single subject instead of teaching chemistry, biology, and physics separately).

At the **lower secondary** level, the required disciplines are native language and literature, Georgian as a second language (for minority students), two foreign languages, mathematics, natural sciences (chemistry, physics, and biology), social sciences (history, geography, and civic education), information and communication technology, music, art, and physical culture.

Presently, the Ministry of Education and Science is carrying out the Education Reform Project—Project *Ilia Chavchavadze*[6] aimed at the transformation of the primary, general secondary, and higher education system of Georgia. The Education Reform Project is comprised of the following subcomponents: teachers' professional development, unified national examinations, national curriculum and textbooks, education system policy and strategy, education management information system, and public relations.

Georgia has participated in the most recent TIMSS cycle (TIMSS 2007) amidst the ongoing reform. In particular, the very goal of the reform implies that in the long run, its results should help increase achievement results in future TIMSS cycles.

Language and Population

The official language of Georgia is Georgian. It belongs to the Iberian-Caucasian family of languages, which has developed and evolved only in the Caucasus region.[7] Georgian has its own alphabet and a rich literary heritage that includes poetry and prose dating as far back as the fifth century. Georgia is a country with many ethnic groups, including Russians, Armenians, Azeris, Abkhazians, Ossetians, Greeks, Jews, and Kurds. These groups commonly speak their native languages, including Russian, Armenian, Azeri, Abkhaz, Ossetian, Greek, and Kurdish. Of these groups, the Abkhazians and Ossetians have autonomous republics in the territory of Georgia.

The main language of the student's school determines the languages in which instruction is given. In particular, instruction in mathematics and science in the fourth and eighth grades is given in Georgian in the Georgian schools and in the minority languages of Russian, Azerbaijanian, or Armenian in the Russian, Azerbaijanian, and Armenian schools, respectively.

Emphasis on Mathematics and Science

Traditionally, school Olympiads in mathematics and science have been a major component in the national policy for encouraging students with the inclination in these disciplines to study mathematics and science more in depth. Nationwide, the Olympiad system is funded by a special program of the Ministry of Education and Science. In 2008, under this ongoing program, a new competition of the Olympiad organization was declared for mathematics, physics, and computer science.[8]

Overarching Policies Related to Education and the Curriculum for Mathematics and Science

One of the major goals of the Education Reform Project, which is currently underway, is the development of a nationwide curriculum and textbooks, including mathematics and science.[9]

The National Curriculum includes teaching and learning principles, subject educational standards, and program content. The National Curriculum is beyond the frames of the teaching programs or standards and represents a unified description of the educational process.

The teaching and learning principles describe the priorities that should be observed when dealing with students, the system of evaluation, guidelines for methodology, the means to effectively organize extracurricular time, and the number of subjects and their distribution in time allocation tables.

Educational standards comprise the attainment targets for each class and those indicators that show whether or not a particular attainment level (outcome) is achieved. The major guideline for developing the standards is to define the minimum required level of information, skills, and attitudes developed by the student.

The program content describes the kind of material through which educational standards can be achieved. In the program content, recommendations regarding the possible texts, topics, and problems are given.

The National Curriculum aims to achieve those goals described in the National Goals for General Education.

The Mathematics Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Mathematics Through Eighth Grade

The goals of mathematics teaching in general primary and secondary school include the following skills.

- Development of thinking abilities
- Development of abilities for deductive and inductive reasoning, proving assertions, and analyzing phenomena and facts
- Mastering mathematics as a universal language for the scientific description of the universe
- Understanding the role of mathematics as a component of the universal human culture
- Preparation for subsequent stages of study or professional development
- Transfer of the knowledge necessary for solving everyday life problems and the development of skills for the practical application of this knowledge.

In forming and developing the above-mentioned skills, only the corresponding background (concepts, statements, and procedures) is used.

The national mathematics curriculum is conventionally subdivided into four principal domains: numbers and operations; geometry and spatial reasoning; data analysis, statistics, and probability; and algebra. These domains are tightly interconnected and encompass the knowledge and skills that a student must master during their studies in general school. The subdivision of the curriculum into domains does not imply a similar subdivision of the course. It only provides a range of the material to be taught and points out what should be given more attention in various stages of teaching. The four principal domains include the following content.

- *Numbers and operations*: numbers, their uses, and ways of representing numbers; operations on numbers and numerical relations; estimation and the approximation of quantities; and quantities, measurement units, and other uses of numbers.
- *Geometry and spatial reasoning*: geometric objects and their properties, interrelations, and constructions; measure and measuring means; transformations and symmetry of figures; and coordinates and their uses in geometry.
- *Data analysis, probability, and statistics*: data sources and data collection methods; ways of organizing data and means of data representation; summarizing

numerical characteristics of data; probabilistic models; and sampling methods and numerical characteristics of samples.

- *Algebra*: sets, mappings, functions, and their uses; elements of discrete mathematics and their uses; algorithms and recursion; and algebraic operations and their properties.

As mentioned above, the National Curriculum includes the content of the program for each grade. Exhibit 1 shows what students are expected to achieve by the end of the **fourth grade**, and Exhibit 2 shows what students are expected to achieve by the end of the **eighth grade.**

Exhibit 1 Mathematics Curriculum Content in Georgia Through Grade 4

Direction			
Numbers and Operations	**Algebra**	**Geometry and Spatial Reasoning**	**Data Analysis, Probability, and Statistics**
Express, compare, and order numbers using a positional system Perform addition and subtraction operations on natural numbers using various methods Perform multiplication and division operations on natural numbers using various methods Distinguish, name, and compare parts of a whole (half, third, quarter) Use and interrelate various measurement units	Construct, express, and investigate correspondences Construct and use algebraic expressions in solving simple mathematical problems	Describe geometric figures and classify them Create graphical images and models of flat and three-dimensional figures Find sizes of objects and figures and distances between objects Perform orientation on a scheme and create simple route schemes	Collect qualitative and quantitative data for a given topic or investigation of an object Order quantitative and qualitative data Perform interpretation and elementary analysis of qualitative and quantitative data

Exhibit 2 Mathematics Curriculum Content in Georgia Through Grade 8

Direction			
Numbers and Operations	**Algebra**	**Geometry and Spatial Reasoning**	**Data analysis, Probability, and Statistics**
Use a positional system and standard form of number recording Perform operations on rational numbers and evaluate operation results Use some methods of argument and proof Solve some problems requiring calculations	Recognize, analyze, and express linear dependence between quantities Use systems of equations and inequalities to solve problems	Use properties of figures to compare and classify types of figures Find sizes of a figure and/or its elements Substantiate validity of geometric statements	Collect data and represent them in a form convenient for solving the posed problem Recognize random phenomena and calculate event probabilities Use the connection between relative frequency and probability to estimate event probabilities and argue about event feasibilities

The Science Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Science Through Eighth Grade

Contemporary general education standards presume that it is important to equip students with the knowledge and skills that enable them to follow rapid developments in mankind's progress so that they can use the achievements of modern science and become well-adapted members of society. The student must be transformed from a passive receiver of information into an active researcher able to use obtained knowledge both for professional success and for the benefit of society.

During the teaching of science, emphasis on attitudes and development of skills, research, and the use of knowledge is a requirement both of contemporary pedagogical methodology and Georgian classical didactics. According to Jacob Gogebashvili, the principal goal in studying nature is "to open for the youth compassion for nature, induce love for its investigation and its contemplation."[10]

A student is able to master any topic more efficiently by actively participating in the research of the topic of study and satisfying his or her own curiosity, not only by investigating principal material but by acquiring information, working with models, and participating in the interactive learning process. Thus, in the teaching of scientific topics, special attention is focused on the development of specific skills.

The study of science focuses on the research of life processes and physical and chemical phenomena. To master science, it is necessary to develop those specific skills which relate to the study of the environment. The science skills, which are the focus of teaching in Georgia, are listed and explained in Exhibit 3.

Exhibit 3 Science Skills in Georgia

Research Skills	Explanation
Observation and description	Determination of the characteristics of objects and phenomena using one's senses and simple devices
Accounting	Writing down, sketching, etc. of observation results
Classification	Grouping of objects and phenomena according to their characteristics
Measurement and the use of quantities	Quantitative description using appropriate measurement units, determination of space-time relationships, and singling out variable characteristics
Communication	Use of written and oral communication, graphs, tables, diagrams, and other means of presentation (including those involving technologies)
Contemplation and hypothesis formulation	Expressing suppositions concerning expected consequences
Planning	Determination of the succession of actions
Conducting experiments	Choice of methodology and the collection of experimental data
Data interpretation	Analysis and generalization of one's own data or those obtained by others
Creation and use of models	Modelling of phenomena

The above-mentioned skills are developed stagewise in all stages of study, taking into account the mental and physical abilities of students. Exhibit 4 presents the development of skills by stage, Exhibit 5 presents the expected achievement by students by the end of **fourth grade**, and Exhibit 6 displays expected achievement by the end of **eighth grade**.

Exhibit 4 Development of Science Skills by Stage in Georgia

	Primary School	Basic School
Research Skills	Posing questions about objects and phenomena and seeking ways to answer them	Posing questions about objects and phenomena aimed at their research
	Collecting data by immediate observation or simple experiments	Collecting data by immediate observation, experiments, and/or various information sources
	Using devices appropriate for the age to collect data	Using devices to collect data and/or improve the observation process
	Using simple ways to present data/information (text, pictures, maps, tables)	Presenting data using various methods (tables, graphs, mathematical, and physical models)

Exhibit 5 Expected Student Achievement in Science by the End of Fourth Grade in Georgia

Direction			
Living World	Bodies and Phenomena	Earth and the Universe	Mankind and the Environment
Describe the lifecycles of organisms Discuss extinct organisms Relate adaptation properties of organisms to the environment	Relate the equilibrium of bodies with the lever principle Distinguish heat conductors and nonconductors Distinguish materials and discuss their properties	Determine absolute and relative positions of objects on a map Discuss the form of the Earth Investigate significant geographic objects in Georgia Describe changes in the environment caused by natural phenomena	Follow rules of social hygiene and safe behavior Investigate modes of life of mankind in various environments Perform interpretation and elementary analysis of qualitative and quantitative data

Exhibit 6 Expected Student Achievement in Science by the End of Eighth Grade in Georgia

Direction		
Live World	Physical Phenomena	Chemical Phenomena
Relate the structure of the cell with its functions Investigate specifics of organism development Describe the transfer of energy and substance exchange in ecosystems Relate diversity of organisms to the evolution process	Describe accelerated motion of bodies Decribe motion and the interaction of bodies Characterize the equilibrium of bodies Characterize the interaction of charged bodies Describe thermal, chemical, and magnetic actions of electric currents	Describe the relationship between simple and compound substances Use the periodic table to characterize elements Relate properties of substances with electron structures of atoms and kinds of chemical linkages Perform quantitative calculations for solving chemical problems

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Time

An academic year consists of at least 180 days, beginning in September and ending in June. The vast majority of schools teach 5 days a week. The total amount of time spent in lessons for grades 1–12 ranges from 21 to 36 hours a week. According to the National Teaching Plan developed by the National Curriculum and Assessment Center,[11] there currently are minimal teaching hour amounts in mathematics and science. For grade 4, these minimal amounts are 5 hours per week (180 hours per year) for mathematics and 4 hours per week (144 hours per year) for the sciences (biology, chemistry, and physics). For grade 8, the minimal amount for both mathematics and science is 4 hours per week (144 hours per year). Schools are free to teach extra hours beyond these amounts.

Instructional Materials, Equipment, and Laboratories

The National Curriculum and Assessment Center applies an approval procedure for textbooks and instructional materials.[12] These materials are not mandatory or recommended. School administrations are free to choose from the existing variety of instructional materials.

In the 2007–2008 school year, the list of approved textbooks included four textbooks in mathematics and five textbooks in science for grade 4 and two textbooks in mathematics, five in physics, three in chemistry, and two in biology for grade 8.

The National Curriculum and Assessment Center has introduced an original scheme for developing textbooks and other instructional materials,[13] based on the monitoring of performance of existing new entitled textbooks in 100 schools in Georgia. Feedback from these schools is conveyed to the authors and the publishers of instructional materials. Meetings between teachers of the monitored schools, textbook authors, and publishers, as well as experts from the National Curriculum and Assessment Center are being organized and held regularly.

Use of Technology

The Ministry of Education and Science of Georgia, with the assistance of Estonian experts from the Tiger Leap Foundation of Estonia, launched the Georgian state schools computerization program, called Deer Leap, the Georgian name for the Milky Way (ირმის ნახტომი)[14] in March 2005. The main goal of the program is to facilitate the modernization of the education system in Georgia by creating a countrywide school-based information and communication technology (ICT) infrastructure and build capacity in modern information technology.

The Deer Leap Foundation was established in September 2005 at the Ministry of Education and Science by a decree of the President of Georgia. The supervisory board of the foundation is extremely representative and includes senior officials from the Ministry of Education, the Ministry of Economic Development, the Georgian National Communications Commission, the parliament, prominent representatives of the Civil Society organizations, and business associations, universities, and the teachers' community.

Deer Leap is a 4-year program with a strong prospect of at least one more 4-year extension phase that will cover all 3,000 state schools currently in existence in Georgia. The 2005–2011 program will provide the following.

- Access to computers (with a student-computer ratio of 20:1) and the Internet in each school
- Availability of educational software and services
- Availability and the quality of technical support
- ICT skills for teachers and students
- Integration of ICT into the curriculum
- Integration of an education management information system on the school, district, and national levels.

Teachers and Teacher Education

Education and Training for Fourth and Eighth Grade Mathematics and Science Teachers

In compliance with the Law on General Education of 2005, teachers are hired by individual schools. The Ministry of Education and Science determines the formula used to calculate the minimum salary for teachers. This formula takes into account the number of lessons taught by teachers, their background, job seniority, and the average number of students taking lessons.

In accordance with the Conception of Teachers' Professional Development, adopted in 2006, only persons with an academic degree (bachelor's or master's) in the field of education who have successfully passed a 1-year probation period and a certification examination have the right to become a teacher. A certified teacher is required to update his or her certificate every 8 years.

Teacher Professional Development in Mathematics, Science, and Technology

The Teacher Professional Development Center of Georgia performs a wide range of tasks for teacher probation, certification, and professional development. The Teacher Professional Development Center seeks to raise the status and standing of teaching in Georgia by maintaining and promoting the highest standards of professional practice and conduct in support of teachers and students and the general public.

The Teacher Professional Development Center works in cooperation with the wider pedagogical and academic community to prepare recommendations for the government with regard to the teaching profession. In particular, the Teacher Professional Development Center of Georgia has a special program for the professional development of teachers.[15]

Currently underway is a program to develop standards for the certification of teachers, which is a joint effort between the Teacher Professional Development Center and the National Examination Center.

Examinations and Assessments

National or Regional Examinations

Before 2006, students in elementary and upper secondary school were assessed using a system of marks. Marks from 2 to 5 were used to measure student achievement, 3 being the minimal passing mark and 5 indicating excellence. Summative assessments were held at the end of each term, mainly in the form of written tests at all levels.

Since 2006, a scale from 1 to 10 has been used for assessing student achievement. There are no marks used in grades 1 to 4, although students receive comments from the teacher at the end of each trimester. Teacher-made tests and locally developed tests also are used in classrooms.

As a part of education reform in Georgia, a state assessment of student achievement in mathematics was conducted in 2004 by the National Examinations Center for grades 1–4.[16] Centralized tests were prepared by the center and administered across the country. Standardized tests in mathematics that were used in the state assessment have been published by the center.[17] These tests are used by schools to assess student achievement levels. There are no national examinations at the elementary level.

Grade Promotion and Retention Policies

In the upper grades, student promotion is evaluated based on grade point average.

References

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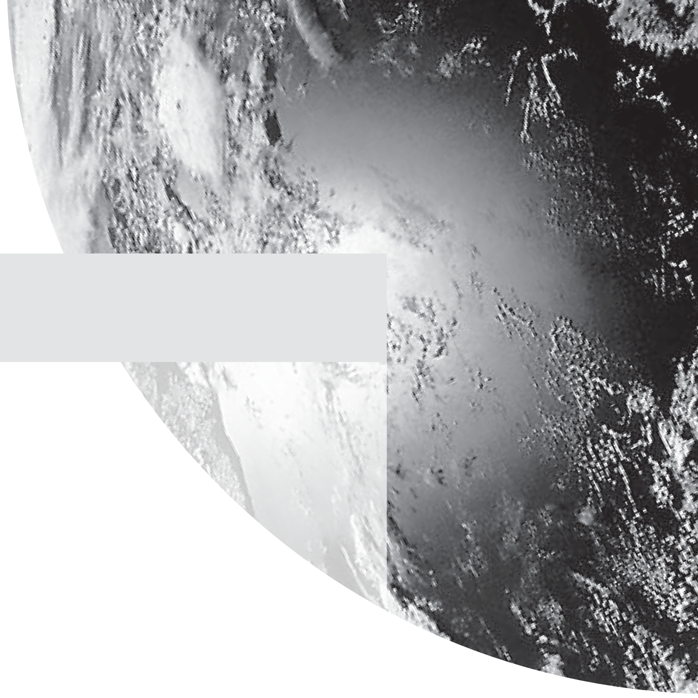

Germany

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Introduction

Overview of Education System

Germany is a federal republic consisting of 16 federal states, the *Laender*. Each federal state has legislative and administrative power over all cultural policy issues within its geographic boundaries including its education system. The individual ministries of education join in the Standing Conference of the Ministers of Education and Cultural Affairs of the *Laender* in the Federal Republic of Germany to collaborate on matters of education, science, research, and culture. A treaty between the federal states standardizes certain crucial aspects of the German school system across the federal states, such as the definition of a grade scale or the total duration of compulsory education.

Within the framework of the *TIMSS 2007 Encyclopedia*, North Rhine-Westphalia, the largest federal state in terms of population, serves as a reference in this chapter in cases where the specificity of particular questions makes it impossible to give valid answers for all federal states.

The organization of the mathematics and science curriculum lies within the responsibility of the Ministry of Education and Cultural Affairs in the federal states. Most federal states appoint a commission consisting of different experts in the specific field of education. This commission devises a curriculum for a certain subject at a specific type of school. Occasionally a curriculum will be launched on a trial basis before becoming universally valid. Furthermore, the commission may consult associations and also parent and student representative bodies to finalize the curriculum. The formulation of curriculum is general enough to provide teachers with the necessary pedagogical freedom.

Current development concerning curriculum policy, beginning with primary school, is centered on educational standards (*Bildungsstandards*). These objectives, which are binding for all federal states, have been implemented nationwide since 2004. They specify the curricular elements for core subjects that are to be achieved by students after a defined number of school years. Thereby, in each federal state, the curriculum functions as an outline on how to reach these goals.

In primary school, educational standards exist for German and mathematics after completion of year 4. For the end of basic lower secondary education, educational standards exist after grade 9 for German, mathematics, and the first foreign language. Educational standards exist for lower secondary education after grade 10 in German, mathematics, the first foreign language, biology, chemistry, and physics.

Preprimary education generally concerns children ages 3–6. It is not part of the compulsory school system and, in general, it is not free of charge. If the education facility is publicly maintained, it is financed by the local authority, the federal state, and parental contributions. If it is privately maintained, it is additionally financed through the maintaining body itself. The function of preprimary education is not explicitly academic. Thus, no official curriculum is provided. In order to address language deficiencies in children with an immigrant background, preprimary education fosters children's language competencies to compensate for educational shortcomings.

In general, children enter **primary school** at the age of 6 and remain for 4 years until age 10. However, Berlin and Brandenburg have 6 years of primary school. After finishing primary school, children are assigned to different types of schools (forms) according to their level of ability (school grades) and their estimated academic potential. In sharp contrast to the highly streamed educational policy that is characteristic of the German secondary school system, primary school in Germany is comprehensive and without tracking or streaming.

Mandatory subjects in primary school include German, mathematics, general scientific knowledge, art, music, physical education, and religious education (and English in some federal states).

Secondary education is divided into lower and upper secondary education. Lower secondary education starts at grade 5 (in the two federal states mentioned above, it starts at grade 7) and ends at grade 9 or 10 (ages 10–12 until ages 15 or 16). Upper secondary education comprises grades 11 to 12 or 13 (ages 15 or 16 until 18 or 19).

Secondary education places most students basically into one of three school forms, mainly based on their performance in primary school. The three classical school forms are the following.

- *Hauptschule* (basic general education): This form includes grades 5 (or 7) to 9 or 10 and entitles its students to proceed to vocational training or to higher forms of secondary school. In 2006, 23 percent of German students in grade 8 attended a *Hauptschule*.
- *Realschule* (extensive general education): This includes grades 5 (or 7) to 10 and entitles its students to proceed to vocational training, to higher forms of secondary school, or to the vocationally oriented upper secondary school (*Fachoberschule)* where students may qualify for universities of applied sciences. In 2006, 27 percent of German students in grade 8 attended a *Realschule*.

- *Gymnasium* (intensified general education): This form includes grades 5 (or 7) to 12 or 13. Successful completion of this form leads to acquisition of the higher education entrance qualification (*Abitur*). In 2006, 33 percent of German students in grade 8 attended a *Gymnasium*.

This is the traditional and most widespread structure of secondary education systems in Germany. Nonetheless, actual school forms existing in the individual federal states may vary considerably from the structure described above. For example, some states have comprehensive schools (*Gesamtschule*) that can substitute for or compete with at least two of the previously described school forms. In 2006, 9 percent of German eighth grade students attended a *Gesamtschule*. Also there are schools governed by private bodies and schools for children with special needs.

Upper secondary education also includes full-time vocational schools and combined vocational programs. The dual system comprises apprenticeship training and education at two sites—the school and the workplace.

Funding for all school forms is mainly provided by the federal states (80%) and municipalities (20%). Within the dual system, businesses providing for apprenticeships contribute to the funding as well. Generally, schools are free of charge for students, except for preprimary education and some private secondary schools or boarding schools. There is no nationally implemented special funding for mathematics and science, yet selectively, programs will address individual schools or regions.

Concerning reforms, the educational standards mentioned above were implemented nationwide in 2004. One special mathematics and science program, the *SINUS-Transfer* program, was developed as a direct consequence of Germany's unsatisfactory performance in TIMSS 1995. One of its core elements is the focus on intensified cooperation among teachers.

Language and Population

The official language and language of instruction is German. Languages of very small minority groups with a long residential background in Germany are regionally acknowledged as official languages as well (Danish, Friesian, and Sorbian). Languages commonly spoken by immigrants are Turkish and Russian.[1]

Among all non-German population subgroups (about 6.7 million or 8% of Germany's total population), the largest is Turkish (about 1.8 million), followed by Italians (approximately 540,000), Poles (approximately 330,000), and Greeks (approximately 310,000). Additionally, in 2004–2005, 3 million other non-German nationals contributed to a total of 18 percent of the population who are immigrants.[2,3]

Emphasis on Mathematics and Science

Many regional measures are in place to encourage students' enthusiasm for mathematics and science issues. Examples include the Universum© Science Center in Bremen; the

Phaenomenta, a science exhibit in five German cities; or cooperative projects between schools and enterprises. In addition, various associations and foundations further contribute to mathematics and science issues. These projects and measures are regional, though, and do not affect all federal states. The project implemented in most federal states is *SINUS-Transfer (Grundschule).*

Overarching Policies Related to Education and the Curriculum for Mathematics and Science
The unsatisfactory performance of German students in international comparative studies (e.g., TIMSS 1995, PISA 2000, and PISA 2003) has led to national scientific research projects (*Bildungsqualitaet von Schule—BIQUA,* 2000–2006) that examine factors influencing mathematics and science competence. It also has led to various measures that focus on enhancing the quality of education both on the national and regional levels. The educational standards are certainly among the most influential of these measures.

An additional nationwide measure for fostering mathematics and science education is the further development of the "unified requirements for the higher education entrance qualification" (*Einheitliche Pruefungsanforderungen in der Abiturpruefung—EPA*). The EPA requirements for mathematics were introduced in all federal states no later than 2005 and for biology, chemistry, and physics no later than 2007.

Furthermore, the individual federal states have originated a vast number of initiatives that promote education in mathematics and science on a regional level. As mentioned earlier, the most popular program, aimed at the enhancement of the efficiency of mathematical-scientific-technical lessons, is the *SINUS-Transfer* program. It commenced as a pilot project in 1998 and began its third round in 2007. Thirteen federal states participated in rounds one and two. While *SINUS-Transfer* is aimed at lower secondary education, *SINUS-Transfer Grundschule* addresses primary schools. *SINUS-Transfer Grundschule* began in the 2004–2005 school year in 11 federal states and will be ending in 2009.

Additionally, 11 federal states are taking part in the project Physics in Context (*Physik im Kontext*), 12 federal states are participating in the project Chemistry in Context (*Chemie im Kontext*), and 9 federal states are participating in the project Biology in Context (*Biologie im Kontext*).[4]

The Mathematics Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Mathematics Through Eighth Grade
There are no mandatory national curriculum guidelines until grade 9 in Germany. The educational standards are graduation oriented. Every federal state has its own curriculum for the specific school forms, subjects, and grade levels. For example, the mathematics curriculum guidelines of North Rhine-Westphalia are outlined below for the *Realschule* in Exhibit 1.[5]

Exhibit 1 Example Mathematics Curriculum Guidelines (from a North Rhine-Westphalia *Realschule)*

Content-based Competencies	
Arithmetic/algebra—dealing with numerals and symbols	
	Students…
Ordering	order and compare rational numbers
Operating	execute basic arithmetic operations for rational numbers (mental arithmetic and written arithmetic techniques) aggregate terms, multiply them, and factorize them with a simple factor solve linear equations by trial and error, as well as algebraically and check their calculations by applying the solution
Applying	apply their knowledge about rational numbers and simple linear equations for solving inner- and extra-mathematical problems
Systematizing	give non-mathematical reasons and examples for the extension from natural numbers to rational numbers
Functions—describing and investigating relationships and changes	
	Students…
Illustrating	express relations in their own words, in tables of values, as graphs, and in terms and shift between the different forms of illustration
Interpreting	interpret relation graphs and terms of linear functions
Applying	identify proportional, nonproportional, and linear relations in charts, terms, and real-world situations apply the characteristics of proportional, nonproportional, and linear relations, as well as simple procedures of the “rule of three” for the solution of mathematical and non-mathematical problems compute percentages and base values in real world situations
Geometry—comprehending dimension and form of two- and three-dimensional figures	
	Students…
Conceiving	name and characterize right, isosceles and equilateral triangles, parallelograms, rhombuses, trapezoids, and simple prisms and identify them in real-world situations
Construing	draw triangles from given measures of angles and sides sketch angular illustrations, create nets of cubes and cuboids, and construct bodies
Measuring	estimate and define the perimeter and surface area of triangles, parallelograms, and figures that are made up of these specify surfaces and volumes of cubes, cuboids, and simple prisms
Applying	conceive and justify attributes of figures by means of symmetry, theorems of angles, or congruence
Stochastic Processes—working with data and chance	
	Students…
Collecting data	plan the collection of data, conduct the survey, and use a spreadsheet for data collection
Illustrating	use median, range, and quartiles for the illustration of frequency distributions
Analyzing	use simple experiments of chance for the illustration of stochastic events in everyday situations use relative frequencies of long series of experiments for the estimation of likelihood ascertain the likelihood within simple experiments of chance by means of the rule of Laplace
Evaluating	use likelihoods for the evaluation of chances and risks and for the estimation of frequencies interpret the range and quartiles in statistical illustrations

Exhibit 1 Example Mathematics Curriculum Guidelines (from a North Rhine-Westphalia *Realschule*) (Continued)

Process-based Competencies	
Reasoning/Communicating—communicating, presenting and reasoning	
	Students…
Reading	gather information from simple mathematical figures (text, figure, chart, graphs), restructure, and evaluate them
Verbalizing	exemplify their individual work stages in simple mathematical operations (constructions, arithmetic techniques, algorithms) in their own words and appropriate technical terms
Communicating	compare and evaluate procedures of solution, argumentations, and illustrations
Presenting	present procedures of solution in short, prepared contributions
Associating	find generalizations and specific instances and give examples and counterexamples as supporting notions (e.g., proportionality, quadrilaterals)
Reasoning	use mathematical knowledge for reasons, also through multistep argumentations
Problem solving—understanding, investigating and solving problems	
	Students…
Investigating	analyze patterns and relationships in numbers and figures and construct assumptions
Solving	plan and describe their approach to solving a problem use algorithms for the solution of standard mathematical problems and evaluate answers in terms of practicability examine the possibility of multiple ways for solving a problem use problem-solving strategies apply various forms of illustration (charts, sketches, equations) for the solution of a problem
Reflecting	examine and evaluate results by means of plausibility, rough calculations, or sketches verify procedures of solution
Mathematical modeling—creating and applying models	
	Students…
Mathematizing	translate simple real-world situations into mathematical models
Validating	verify the results generated through the mathematical model by comparing it to the situation and where necessary, modify the model
Implementing	match a mathematical model (chart, graph, equation) with a suitable real-world situation
Instruments—using technologies and instruments	
	Students…
Investigating	use spreadsheets and geometry software for the investigation of mathematical and non-mathematical relationships
Calculating	use a calculator
Illustrating	compile data electronically and depict it by means of a spreadsheet
Researching	use dictionaries, textbooks, and the Internet for the acquisition of information

The Science Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Science Through Eighth Grade

Students should have been taught the topics shown in Exhibit 2, by the end of grade 8 in a comprehensive school[6] in North Rhine-Westphalia. The comprehensive school was chosen as a model because its science curriculum in North Rhine-Westphalia enables interdisciplinary instruction that includes content usually taught in individual science subjects (biology, chemistry, and physics).

Exhibit 2 Example Science Curriculum Guidelines (from a North Rhine-Westphalia Comprehensive School)

Theme	Recommended Topics
Senses and Perception	"The senses convey the environment" Students become acquainted with characteristics of light, acoustics, and visual phenomena. Hereby, they learn about the sense of touch, the visual sense, the sense of taste, and the olfactory sense in humans, animals, and plants. They learn about the loss of individual senses and develop first insights into the structure of organs and the function of nerves.
Discoveries in the microcosm	"Traveling into small worlds" Students acquire insights into the development of visual pictures using the examples of magnifying glass, microscope, and binoculars. They learn about elementary characteristics of different substances and solutions (e.g., stone, salt, water) and about procedures of mixing and separating them. They examine the structure of the different sorts of cells and determine plants and animals.
Animals and plants in their environment	"Habitats: on plants and animals" Students learn about the cultivation of farm animals and useful plants and learn about germination, reproduction, and growth. They concentrate on elementary cycles of life and the year and deepen their knowledge of plants and animals and their adaptation to different biospheres (e.g., in the forest, in the zoo, on a farm). They acquire an overview of the food chain.
The human body and its performance	"Movement—who accomplishes what?" Students learn about forces, the transmission of forces, effects of forces, and weight force in humans, animals, and plants. Furthermore, they learn about speed and its alteration and acquire basic knowledge about air, oxygen, water, and carbon dioxide. They become acquainted with the skeleton, the blood circulation, the muscular system, and the heart and learn about food as a source of energy and about respiration and temperature regulation. In this context, students acquire new knowledge about health and illness and learn about bodily and mental fitness.
Materials in everyday life	"Keeping track of everyday materials" Students deepen their knowledge about mixing and separating everyday substances and solutions. They learn to classify different materials according to their properties, and they learn about particles and aggregate states. They get to know raw materials.
Weather and the rhythm of the year	"The weather in the course of the seasons" Students realize that matter expands when heated. They measure temperature, air pressure, humidity, wind, and precipitation and describe the connection of thermal radiation, aggregate state, and the water cycle. They get to know the sun as the provider of energy and learn about energy transport and energy conversion. They acquire basic knowledge about pressure, buoyancy force, and density. Furthermore, they explore man's influence on climate and weather.
Water—the basis of life	"Water—an important habitat" Students deepen their knowledge of water, air, oxygen, carbon dioxide, and nitrogen and intensify their knowledge of aggregate states and particles. They look at the structure of molecules. They learn about the pollution of water through chemicals from the household and agriculture and about purifying water. In addition, they look into the ecological system, using the example of the water and carbon cycle, the food chain, and photosynthesis. They learn to classify plants and animals and broaden their knowledge of different cells and micro-organisms. They examine oceans, lakes, rivers, and streams as the biosphere of animals and as locations for recreation and tourism.

Exhibit 2 Example Science Curriculum Guidelines (from a North Rhine-Westphalia Comprehensive School) (Continued)

Theme	Recommended Topics
Motion in nature and techniques	"Flying, driving, walking—floating, swimming, diving" Students deepen their knowledge about pressure, buoyancy, and density. They transfer the notion of energy to mechanical procedures and consider the conversion of energy and friction. They widen their conceptions about speed and acceleration. They compare principles of motion in nature to technical analogies. They learn about motion on land (in animals and humans, in track, and in wheel vehicles), in water (in animals and humans and different kinds of boats), and in air (in animals and in different kinds of propeller-driven and jet aircrafts).
Materials change and are changed	"Fire in the history of man" Students broaden their knowledge about attributes of substances, classes of substances, and substance cycles. They learn to discriminate between raw substances and advanced materials and rules for safe contact with hazardous material. They deal with the transformation of substances and in this context, consider substance and energy turnover and acquire knowledge about oxidation and reduction. They apply their knowledge about temperature, thermal expansion, and thermal radiation. They deal with fire in nature (e.g., in lightning or volcanoes), as a means of preparing food or treating metal, in its ritual relevance (e.g., in the sanctuary light or in the Easter fire) and technical significance.
The history of the Earth	"Development of Earth and living beings" Students deepen their knowledge of light, the spreading, reflection, and distortion of light, on forces, the transmission of forces, effects of forces, and weight force, and of speed and acceleration. They develop first conceptions about mass and inertia. Among other things, they deal with planets, satellites, and the seasons of the year, pictures of the universe, telescopes, the atmosphere, evolution (e.g., the era of the dinosaurs), and the future of mankind (e.g., global warming and science fiction literature).
Electricity in nature and everyday life	"Electricity and life" Students learn about electricity: electric charges, electric currents, voltage, and resistance and the generation and storage of electric energy. Concerning this, they learn more about natural phenomena (e.g., lightning), electrical processes in living systems (e.g., power impulses in the nervous system), acquire knowledge about electrical equipment and the electrical circuits in the household, and learn about the history of electricity.
Sunlight and life	"Sun: light and warmth" Study the sun and its influence on the human rhythm of life (e.g., sunlight as a means of healing or the consequences of night employment), as well as that on plants (photosynthesis). They discuss renewable energy and examine the relevance of the sun in different cultures.
Communication and understanding	"Behavior and understanding" Students deepen their understanding of sound waves. They find out about similarities and differences in the propagation of sound and in the transmission of information and signals by electronic media. Students deepen their knowledge about the human senses as a means of communication. They learn about different communication systems in humans and animals, nonverbal communication, writing, and the dependence of communication on the subject of sender and recipient.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Time

In North Rhine-Westphalia, at the end of primary school, about 5 instructional hours are devoted to mathematics and 5 instructional hours to science weekly (one instructional hour is equivalent to 45 minutes). In the eighth grade of comprehensive school, about 4 instructional hours of the weekly instruction time are in mathematics and about 5 instructional hours are in science.[7]

Instructional Materials, Equipment, and Laboratories

In North Rhine-Westphalia, instructional materials have to be approved by one of three methods: general approval, simplified approval, or approval by an advisory opinion.[8] Each subject within a certain school form is allocated to one of the three methods. Published collections of formulas are generally approved for all school forms. Further instructional materials for mathematics and science in primary school have to meet the requirements of the simplified approval. For lower secondary school (all school forms), instructional materials for both mathematics and science require approval by an advisory opinion, as well as the consent of the ministry to implement.[9]

Moreover, there is a directory of approved material that is updated regularly and can be accessed online.[10] Currently, for primary school mathematics, 86 school books or CDs (from 11 publishing houses) are approved and 28 science school books or CDs (from nine publishing houses) are approved. Comprehensive schools can choose mathematics school books or CDs from at least 27 options (from four publishing houses). For biology, there are nine options (from three publishing houses), for chemistry, four options (from three publishing houses), and for physics, three options (from one publishing house).

As for laboratories, the larger schools usually have more functional rooms (for music, arts, handicrafts, and science). Kitchens or rooms for handicrafts may be used for scientific purposes and thus may serve as laboratories as well. Nevertheless, only 8 percent of the German primary schools participating in TIMSS 2007 stated that they had a science laboratory.[11]

Grade at Which Specialist Teachers for Mathematics and Science Are Introduced

In North Rhine-Westphalia, all primary school teachers are obliged to study mathematics as one of their core subjects. Thus, all teachers concerned are specialist mathematics teachers. Since primary school science is a consolidated subject and more general, primary school science teachers in North Rhine-Westphalia do not have to explicitly specialize in the subject. Teachers in secondary school are specialist teachers in mathematics and the specific scientific subjects.

Use of Technology

In 2006, 99 percent of all schools were equipped with stationary and mobile computers (71% of these computers were connected to the Internet).[12] In primary schools, the ratio of students to computers was 12:1 (52% of these were connected to the Internet) and in secondary schools, the ratio was 11:1 (75% were connected to the Internet).

Ninety-three percent of primary schools used computers in mathematics, and 92 percent used them in science. Ninety-two percent of secondary schools used computers in mathematics, and 87 percent used them in science.

Other technology-based devices also were used. Sixty percent of the primary schools were equipped with scanners, 44 percent had digital cameras, 34 percent had video projectors, and 41 percent had DVD players. Among the secondary schools, 87 percent provided for scanners, 85 percent had digital cameras, 89 percent were equipped with video projectors, and 76 percent had DVD players.

Homework Policies

There is no nationally uniform policy concerning the administration of homework. For North Rhine-Westphalia, the Ministry of Education has issued a decree that regulates the cornerstones of homework policy—the timeframe for homework (primary school 30 to 60 minutes and secondary school 90 to 120 minutes), no homework may be assigned from Saturday to Monday, and the regular review of homework by the teacher.[13]

Teachers and Teacher Education

Education and Training for Fourth and Eighth Grade Mathematics and Science Teachers

Teacher education in Germany is presently being restructured from a course of studies terminating with state examinations into a course of studies culminating in a bachelor's or master's degree. Since teachers involved in TIMSS 2007 would all have been educated within the prior system, the former structure of teacher training is presented within this framework.

German teacher education is possible at universities, colleges of education, and colleges of art and music. Entry requires the higher education entrance qualification (in most cases *Abitur*). Teacher education is structured into two phases. Both phases terminate with a state examination (first and second state examination). Passing the First State Examination is a precondition for admission into the second phase, and only after having taken the Second State Examination are teachers qualified to practice their trained profession officially. The first phase (six semesters for primary school teachers and up to nine semesters for secondary school teachers, equivalent to 3 to 4.5 years) focuses on higher education. It includes at least one practical training period of several weeks and incorporates a didactics or subject-related didactics placement. The second phase, preparatory service, usually lasts 18 to 24 months and consists, for the most part, of practical pedagogical training situated in the classroom.

The amount of mathematics and science and the amount of pedagogical training required within teacher training varies depending on the particular federal state and the targeted subject and level of teaching. In North Rhine-Westphalian primary schools, mathematics teachers spend about 20 to 40 percent of their total time studying mathematics and 25 percent studying educational science. The remaining time is spent studying other subjects that can be chosen freely, and this may include science. For primary school science teachers, there is no specific amount of science education required. Secondary school mathematics and science teachers spend about 40 percent of their total time studying their first major subject, another 40 percent to studying their second major subject, and 20 percent to studying educational science.[14]

Courses in educational science usually are included in general and school pedagogy, as well as psychology. Additionally, students may choose between philosophy, sociology or political science, or theology.

Occasionally, if the staff situation makes it necessary, the employment of personnel without formal teacher training is admissible (in 2004, 4.4% of all newly recruited teachers in the public school sector had no formal teacher training).[15]

Teacher Professional Development in Mathematics, Science, and Technology

Generally, teachers are obliged to participate in further education training courses, regulated by law through the federal states. Teacher professional development takes place during working hours. State-run training institutes exist in almost all federal states.

In North Rhine-Westphalia, teachers are required to complete a certain number of hours of professional development, whereby they may choose between thematic subjects the school suggests according to the school's individual demands. In 2002, most of the subject-related courses attended for teacher professional development concerned mathematics, science, and technology (about 40%).[16]

Examinations and Assessments

National or Regional Examinations

Only in the last few years has the discussion about central examinations intensified and led to actual changes in this respect. In accordance with the policy of nationwide educational standards, many federal states already have implemented or are in the process of implementing comparative tests that monitor student achievement across the individual federal state or even across different federal states. Grade levels of administration and other specifications of these tests vary considerably across the states. In the near future, nationwide standardized tests will be implemented to evaluate whether or not the educational standards actually are met.

Beginning with the 2007–2008 school year, such tests will be administered at the end of grade 3 in German and mathematics, and beginning with the 2008–2009 school year, they will be administered in German, mathematics, and in the first foreign language at the end of grade 8. To a certain extent, the results will be comparable on an international level as well.[17] The results of these standardized tests also may contribute to appraisals in final report cards.

Other Tests

Within the upcoming comparative tests, mathematics also will be assessed as a central domain. Commercial tests are not common within Germany's education system with regard to school development or system monitoring.

Monitoring Individual Student Progress

In state-run schools, individual student progress is monitored by the teacher throughout the academic school year. A written commentary on the child's individual strengths and difficulties is supplied by the teacher at the end of grades 1 and 2 (primary school). From grade 3 on, marked class tests are conducted and children receive a report card with marks for each subject every half year.

The Standing Conference of the Ministers of Education of the *Laender* agreed upon a six-mark system for the valuation of student achievement (very good, 1; good, 2; satisfactory, 3; adequate, 4; poor, 5; and very poor, 6). In upper secondary education, a 15-point-system is used.

The grades on final report cards at the end of each school level have consequences for the child's further school career. They determine the level of educational degree the student acquires, as well as dominate the decision as to which school form the student may transfer into.

Grade Promotion and Retention Policies

All primary school students automatically move from grade 1 to grade 2. Beginning with grade 2, children are assigned to a grade either by being promoted to the next higher grade or repeating the present grade, depending on their level of achievement represented by the report card marks at the end of the school year. A student must have adequate grades in all subjects in order to proceed to the next higher grade. A very good (1) or good (2) grade can, under certain circumstances, compensate for a poor (5) grade. If a student's achievement is exceptionally high, compared to the general achievement status of his class, s/he has the possibility of skipping a grade. It is possible to transfer between school forms, moving either upwards or downwards, depending on the individual level of achievement.

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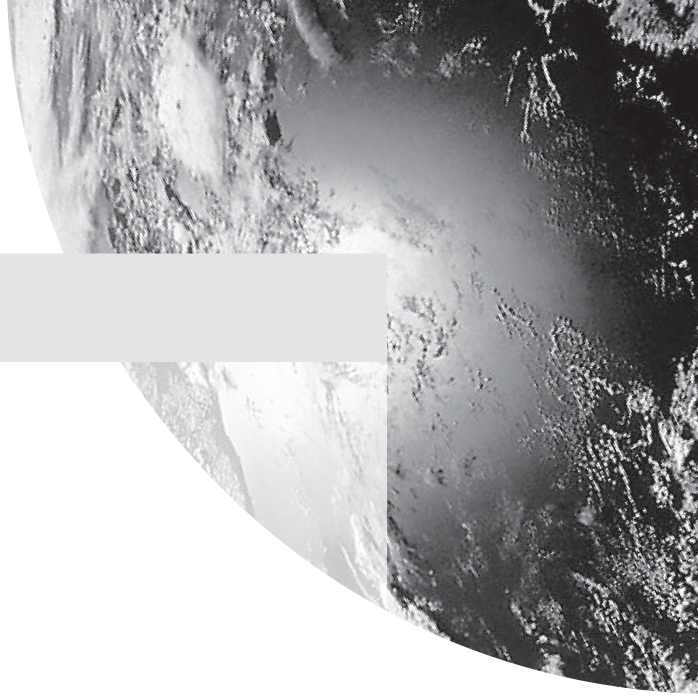

Ghana

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Introduction

Overview of Education System

The Ministry of Education, Science, and Sports is responsible for the formulation of educational policies in Ghana. The ministry ensures that the implementation of policies is in accordance with the aims and objectives of education. The Ghana Education Service, which is operated by the ministry, is responsible for the implementation of approved, pretertiary education policies and programs.[1] Ghana's educational policies are based on the country's constitutional provision on education and include the Free and Compulsory Universal Basic Education policy (introduced in 1996) as well as Education for All (by 2015), based on the World Declaration on Education for All Goals, which focuses on meeting students' basic learning needs.[2] Ghana's national policy on education emphasizes mathematics, science, and technology education.

In Ghana, there has been a substantial increase in school enrollment at the basic level (preschool through junior secondary school) due to the elimination of fees in all public schools in 2005 and the introduction of the school feeding program, which provides meals to children in schools.[3,4] In the 2004–2005 school year, public basic schools had an enrollment of 3,698,479, while in private basic schools, there were 1,189,953 students. The gross enrollment ratio, or the percent of students enrolled from the relevant age group, for preschools increased from 25.5 percent in the 2004–2005 academic year to 30.8 percent in the 2005–2006 school year; for primary schools, from 83.3 to 92.7 percent; and for junior secondary schools, from 70.2 to 76.1 percent.[5] Currently, the total enrollment for both the public and private basic schools stands at over 5,000,000 in about 11,000 preprimary, 16,000 primary, and 8,000 junior secondary schools.[6] The national student-teacher ratio stands at 35 to 1. In the 2004–2005 academic year, enrollment of students at the senior secondary level was 333,002.

To improve on the management and administration of pretertiary education in the country, Ghana's education system, in line with the government's policy, has been decentralized into a six-tier system: school, circuit, district, regional, national, and the ministry.[7] District education offices, established in all 140 districts, are autonomous and managed by district directors of education. For ease of education delivery, schools in the districts exist in circuits and have circuit supervisors and assistant directors in charge of supervision. Regional inspectors monitor and inspect secondary schools and colleges. The Curriculum Research and Development Division of the Ghana Education Service is responsible for researching and developing a national curriculum and writing textbooks. The inspectorate division, also part of the Ghana Education Service, works in collaboration with the regions and the districts to establish guidelines for inspecting schools, as well as to conduct inspections, monitor schools, investigate complaints, and approve courses and programs in all pretertiary schools in the country.[8]

Within schools, the head teachers, masters, or principals are responsible for the management of education. Communities in which these schools are located take part in the drafting and implementation of policies on education. For this reason, school management committees have been established, in addition to the already existing Parents and Teachers Association to take charge of the governance of the basic schools. At the senior secondary level, this is the responsibility of the board of governors.

Ghana's education system is made up of four levels comprising basic education, secondary education, tertiary education, and nonformal education. At the basic level, education is compulsory and in the public education system, tuition free, under the Free and Compulsory Universal Basic Education policy, mentioned previously. As it pertains to TIMSS 2007, two levels, basic and secondary education, are explained below.

Level one is **basic education** and consists of a 2-year preschool (part of the new education reform), 2-year kindergarten, 6-year primary school, and 3-year junior high school.[9] Children, ages 4 and 5, are enrolled in kindergarten and, at age 6, enter a 6-year primary school. The final level of basic education, junior secondary school introduces children to basic scientific, technical, and vocational knowledge and skills.

Among the few preschools in the country, most are owned by private individuals, communities, nongovernmental organizations, and churches. The rest are model preschools which are under the auspices of the Ghana Education Service.

Level two is **secondary education**, which includes senior secondary or technical or vocational education, and is provided at the senior secondary schools, technical or vocational institutes, and through apprenticeship programs. This level has been increased from 3 to 4 years. The curriculum at this level is diversified to cater to the different aptitudes, abilities, interests, and levels of students. Students with high marks on the Basic Education Certificate Examination are selected into the senior high school under the new education reform, whereas those with average marks enter technical or vocational schools.

Schools or educational institutions in the country belong either to the government or to private individuals and are funded accordingly; public schools are state funded while the owners fund private schools. However, as a whole, funding of education in Ghana has been the responsibility of the central government. Expenditure on education, which is approved by Parliament, is between 28 and 40 percent of the national annual budget.[10]

Although policies of the previous and current governments have helped raise the standards of education in the country, the education system is still confronted with a number of challenges. Increases in enrollment at all levels of education imply the need for more classroom or lecture blocks, provision of more learning materials, and adequately resourced laboratories and libraries. As a result, there is a need for training of more teachers at all levels of education and improvement in teacher professional development in all subject areas, especially in mathematics and science. However, the flow of resources into the education sector is not enough to meet demand, even though it is this sector that receives the bulk of the national funds annually. Finally, the use of recent developments in science and technology for economic advancement has necessitated drafting policy to introduce information and communication technology as a subject from the basic to the tertiary level, which will also require additional resources.

Language and Population

English is the official language of the country, and it is the language of instruction at all levels of education. However, there are about 46 languages spoken in the country, out of which only nine are documented. The Ghanaian languages are Twi, Dagaare or Wale, Dangbe, Mole-Dagomba, Ewe, Ga, Gonja, Kasem, and Nzema.[11] These languages are studied in schools, depending on the native language of the community in which the school is located.

The population census, carried out in the year 2000, showed that Ghana's population stood at 18,800,000. However, the population increased to 21,029,853 in 2005 and includes major ethnic groups such as the Akans (49.1%), Ewes (12.7%), Mole-Dagombas (16.5%), Guan (9.8%), and Ga-Adangbe (8%).

Emphasis on Mathematics and Science

The National Science and Technology Policy emphasizes the teaching and learning of science and technology in order to speed up the country's development. The policy states that science should be taught as environmental studies in the lower primary level and as an integrated science at the upper primary and junior secondary school levels.[12] This policy has led to the appointment of science, technology, and mathematics education coordinators in the 140 district education offices to supervise the teaching and learning of science and mathematics in their districts.

To enhance the teaching and learning of science and technology in schools, a National Science Education Unit, headed by a director, as well as a Science Resource Center in each region have been established. The centers offer students access to science laboratories and libraries in addition to periodically organized clinics or workshops for junior secondary school and senior secondary school students.

Overarching Policies Related to Education and the Curriculum for Mathematics and Science

The mathematics and science curriculum used for TIMSS 2007 was from 2001. After Ghana's participation in TIMSS 2003, a country report was made available to the Ministry of Education, Youth, and Sports; the West African Examinations Council; and other stakeholders. As a result of this report, test items used in mathematics and science assessments have begun to change from requiring memorization and recall to the application of mathematical and scientific knowledge acquired. Training of mathematics and science teachers was organized throughout the country to update them on teaching and learning skills based on contemporary methods of assessment. Teachers were taught to write test items that measured application and analysis of mathematical and scientific concepts, in addition to those on recall.

The government has embarked upon a comprehensive review of the education system and among the key areas of focus are curriculum development and textbooks production.[13] The new curriculum, which took effect in September 2007, has made the mathematics curriculum for primary education activity oriented. The junior high school curriculum, on the other hand, has introduced higher cognitive skills such as synthesis and evaluation and the number of major content areas was reduced.

The government policy on science and technology informed the Curriculum Research and Development Division on the development of the science curriculum. The new science curriculum, which took effect in September 2007, introduced natural science to the primary school (1–6), in place of environmental studies, integrated science into the junior high school curriculum, and put emphasis on higher cognitive skills such as synthesis and evaluation.

The Mathematics Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Mathematics Through Eighth Grade

The goal of the 2001 mathematics curriculum, as designed by Curriculum Research and Development Division, was to ensure that students were equipped with competencies in the knowledge and application of basic mathematical knowledge and skills.[14,15]

The concept of using profile dimensions was made central to the mathematics curriculum, beginning in 1998. Knowledge and understanding (basic knowledge) and the application of knowledge for mathematics were made the prime focus of teaching and learning. The profile dimensions were weighted differently for primary 1–3, primary 4–6, and junior secondary school 1–3. Although more weight was given to the application of knowledge in the intended curriculum, that was not how it was implemented in the classroom, where a lot more emphasis was put on knowledge and understanding. The primary school curriculum prescribed that knowledge and understanding should be weighted 40 percent and application of knowledge weighted 60 percent. The junior secondary school curriculum prescribed that 30 percent of learning should be based on knowledge and understanding and 70 percent on application of knowledge.

The profile dimensions enabled the teacher to state specific behavioral objectives. The curriculum was organized according to topics (content) and specific objectives, which defined concepts, teaching and learning activities, and evaluation indicators for the teacher. The time allocation for lessons also was stated. The curriculum for primary and junior secondary schools was structured to cover the first 6 years of primary education and 3 years of junior secondary school education, respectively, with each year's work divided into units. Based on the 2001 curriculum, the mathematics content areas for primary and junior secondary school are as follows.

In **primary school**, the mathematics curriculum covered the following major content areas: numbers, shapes and space, measurement, collecting and handling data, problem solving, and investigation with numbers. Students were required to acquire basic knowledge and principles in these topics and to be able to apply these to everyday life situations.

In **junior secondary school**, the mathematics curriculum covered the following major content areas: numbers, shape and space (geometry), algebra, estimation and measurement, collecting and handling data, problem solving, and investigation with numbers, sets, relations, and functions. Students were expected to acquire the ability to differentiate (analyze), compare, distinguish, and identify significant points. They also were expected to compile (synthesize), combine, devise, plan, design, and generate new ideas and solutions. Additionally, students were required to compare (evaluate), contrast, justify, criticize, support, discuss, conclude, and make recommendations.

The Science Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Science Through Eighth Grade

The goal of the science curriculum, as designed by Curriculum Research and Development Division, was to ensure that students were equipped with competencies in the knowledge and application of basic scientific knowledge and skills.[16,17]

As in mathematics, the concept of profile dimensions was made central to the curriculum beginning in 1998. Knowledge and understanding, application of knowledge, and attitudes and skills were made the prime focus of teaching and learning of science. The profile dimensions were weighted differently for primary 1–3, primary 4–6, and junior secondary school 1–3. In primary education, the three profile dimensions that were specified for teaching, learning, and testing allocated 40 percent to knowledge and understanding, 40 percent to application of knowledge, and 20 percent to attitudes and process skills. In junior secondary school, 30 percent was allocated to knowledge and understanding, 40 percent to application of knowledge, and 30 percent to attitudes and process skills. It was expected that junior secondary school students would have the ability to apply rules, methods, and theories to real-life challenges that were new and unfamiliar. They also should be able to differentiate, compare, distinguish, outline, and identify significant points to enable and make inferences from facts.

The curriculum was organized in the same way as mathematics in regard to content, specific objectives, the division of the work into sections and units, and time allocation for lessons in primary and junior secondary school. Based on the 2001 curriculum, the science content areas for primary and junior secondary school are as follows.

In **primary school**, science focused on environmental studies. The content includes the study of plant and animal life, water and other liquids, air, food, soil, and care of the body at the lower primary (1–3) level. In addition to these topics, sound, heat, light, electricity, metals and magnetism, and the sky and heavenly bodies were taught in the upper primary level (4–6).

The environmental studies curriculum was designed to equip students with basic concepts including those in science concerning phenomena in their environment, the inter-relationship of living things and their surroundings, and the basic scientific knowledge necessary to appreciate and solve simple problems in their environment. Students were assisted in developing relevant process skills, which guided them to explore their environment. They were taught to develop desirable attitudes and interests, at their level, by asking questions, finding solutions to problems, showing positive interest in their natural environment, and forming the habit of thinking in a systematic way.

In **junior secondary school**, 1–3, science was taught as an integrated science, and it is still being taught as such even though changes have been made to the 2001 curriculum. The 2001 curriculum for the junior secondary school was divided into sections and into units. The number of sections differed from class-to-class. Each unit had specific objectives.

The major content areas or sections that needed to be covered before the end of junior secondary school 3 were as follows.

- Introduction to science, including the nature of science and matter
- Water sources, uses, and purification of types of water
- Life processes, such as food and nutrition, reproduction and growth, the structure and function of teeth, and heredity
- The environment in relation to hygiene and health, safety, soil, pollution, and the weather
- Technology and development related to food processing, and community development
- Chemical substances, including chemical elements, compounds and mixtures, and physical and chemical changes
- Energy and forms of energy
- Transport, such as diffusion and osmosis, circulatory systems in humans, and force and density
- Machines
- Metals and nonmetals including alloys, and rusting.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Time

Instructional time for mathematics and environmental studies at upper primary consisted of nine and six periods per week, respectively, each 30 minutes. In the junior secondary school, the time allocation for mathematics and integrated science were 10 and four periods per week, respectively, with each period lasting 30 and 35 minutes, respectively. These periods were put together into double periods rather than single periods.

Instructional Materials, Equipment, and Laboratories

The central government and the district assemblies provide schools with science and mathematics textbooks, as well as supplementary readers. Textbooks are produced by private publishers and the ministry evaluates and selects these for all schools. Teachers create supplementary materials such as pamphlets and handouts to help teach mathematics and science. The education component of the National Science and Technology Policy document encourages individuals, publishers, subject associations, and professional bodies to develop and write textbooks, as well as produce science, technology, and mathematics educational equipment. Writers were expected to incorporate appropriate problems requiring mathematical and scientific thinking, rather than memorization and recall. Basic schools in the country did not have laboratories since there was no policy with respect to that.

Grade Specialist Teachers for Mathematics and Science Are Introduced

Teaching mathematics and science at the primary level does not require specialized training in mathematics and science since there is no teaching by subject at that level. However, teachers with basic mathematical and scientific knowledge are encouraged to teach primary education. In the junior secondary school, where there is subject-specific teaching, trained mathematics and science teachers are required to teach these subjects. Notwithstanding, there is a general shortage of mathematics and science teachers in Ghana schools.

Use of Technology

Although there was a national policy on information and communication technology (ICT), which mandated the teaching of simple concepts and application of ICT at the basic level, only a few basic schools in the country had access to computers, most of which were private schools.[18] The current curriculum on ICT, for all levels of pretertiary education (kindergarten to junior secondary school), gives instruction on the use of computers for teaching and learning.[19]

Homework Policies

It is expected that every teacher will give students assignments after the completion of each lesson.

Teachers and Teacher Education

Education and Training for Fourth and Eighth Grade Mathematics and Science Teachers

Teacher education and training in the country is streamlined to take care of all four levels of the education system. For preschool, there is the 3-month preschool teacher training course, which leads to the awarding of a Nursery Teacher's Certificate. Teachers at the basic level are given a Teacher's Certificate A, after a 3-year postsecondary teacher training program. Only 6.5 percent of students who enter teacher training colleges pursue science. Currently, there are 38 teacher training colleges in the country. The Teacher Education Division of the Ghana Education Division has responsibility for these colleges,[20] which now have been upgraded to diploma-awarding colleges of education. In line with this, the teacher training colleges now award diplomas in basic education after 3 years of training.[21,22] To enhance the teaching and learning of mathematics, science, and technology in the basic schools and also to produce adequate numbers of mathematics and science teachers, the ministry has selected 15 teacher training colleges to specialize in the training of mathematics and science teachers. This was an intervention put in place to address the need for more mathematics and science teachers in Ghana's schools and also a recognition of the importance of science and technology to the development of a country.

As minimum entry requirements for the 3-year teacher training in colleges, which offers science and mathematics as the major subjects, prospective teachers must pass courses in English, mathematics, and either life skills or the Ghanaian language, as well as two elective subjects in science, agriculture, or any of the technical subjects.

Teaching at the secondary level requires a diploma or degree obtained after a 2- to 4-year program at the polytechnic or university. To be able to teach at the tertiary institutions, one should have obtained a master's or a doctorate degree in the subject discipline.

Although most basic schools in the urban centers are equipped with teachers, rural schools lack teachers, especially in science and mathematics. In line with this, incentives, such as accommodations, motorbikes, bicycles, and home appliances, are being provided to motivate teachers to accept positions in rural areas.

Teacher Professional Development in Mathematics, Science, and Technology

Teachers can improve upon their professional status by progressing through the ranks and taking a leave to study subjects and programs in higher educational institutions approved by the Ghana Education Service. Programs in mathematics and science are encouraged. In addition, distance learning modules have been provided under the Free Compulsory Universal Basic Education policy to upgrade teachers through continuing professional education in the country's universities. Short courses in institutions outside the country also are offered to update teachers' skills.

Additionally, to promote good pedagogical practices, teacher professional development and workshops on learning goals and appropriate teaching methods in areas that are identified as particularly weak are organized by schools and district education offices.

Examinations and Assessments

National or Regional Examinations

There are no high stakes examinations from kindergarten through junior secondary school. At the end of the 3-year junior secondary education, students sit for the Basic Education Certificate Examination, which is a national examination and hence taken throughout the country by junior secondary school students in year 3 (grade 9). This examination is very important since students are admitted to the senior secondary level based on their performance on this examination.

The West African Secondary School Certificate Examination is another high stakes examination. It was a national examination but now is a regional examination administered by the West African Examinations Council in five English-speaking countries in West Africa: Ghana, Nigeria, Sierra Leone, Gambia, and Liberia. This examination is taken at the end of the 4-year senior secondary education and the results are used for admission into university, polytechnic, and teacher training colleges.

Other Tests

In addition to the two high stakes examinations, there are a few assessment systems that assess the curriculum used in the schools, and these are carried out periodically. These include TIMSS for junior secondary school, year 2 students; the National Education Assessments for primary schools that assesses numeracy and literacy; and continuous assessments used at all levels of pretertiary schools. Among these, TIMSS is the only assessment in the country that specifically addresses mathematics and science.

Monitoring Individual Student Progress

Marks are awarded to students for the subjects in which they are tested and recorded in report cards at the end of every school term. The report cards are duly signed by their class teachers, form teachers, and head teachers to authenticate them. These report cards monitor student performance as they progress from one grade or class to the next. Students in all junior secondary school classes are assigned grades in line with those given after their Basic Education Certificate Examination.

Grade Promotion and Retention Policies

The policy regarding promotions in schools is strictly adhered to by all public schools. All students are automatically promoted to the next class, irrespective of their performances on tests. However, this does not apply to private schools, where students are retained when they do not do well at the end of the school year. The new educational reforms may look at this policy once again, since it has identified automatic promotion as one of the ways it lowers the standards of education.

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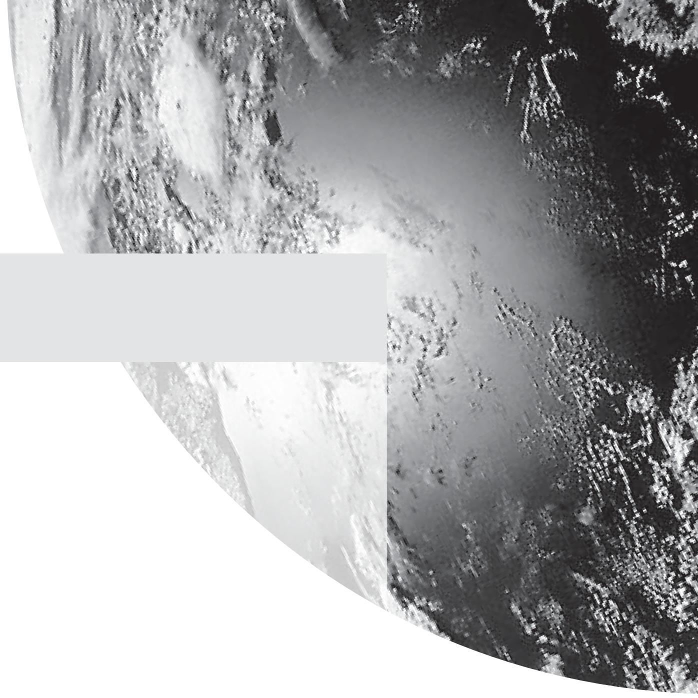

Hong Kong SAR

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Introduction

Overview of Education System

The government of the Hong Kong Special Administrative Region (SAR) always has attached great importance to education. The Education Bureau, which is responsible for the formulation of policies and the introduction of legislation in respect to education from preprimary to tertiary levels, ensures that quality education is provided for Hong Kong's young people and oversees the effective implementation of educational programs.[1]

The Curriculum Development Council is a free-standing advisory body appointed by the chief executive of the Hong Kong SAR to give advice to the government on matters relating to curriculum development for the local school system from preprimary to the sixth form.[2] Its main tasks are the following.

- Setting the general directions of curriculum policies in school education
- Formulating directions of development in key learning areas and mapping out plans and strategies for the development of different curriculum organizations
- Advising on matters related to the conduct of research and development of learning resources in support of all levels of schooling and for children with special education needs.

The Curriculum Development Institute is a division of the Education Bureau, providing professional leadership in the development of the school curriculum in Hong Kong and collaborating with local and international partners in the development of quality curriculum. Besides providing secretariat support to the council, it supports schools in the implementation of curriculum policies and innovations in the following ways.

- Provides schools with a coherent, broad, and balanced curriculum, which has a flexible curriculum framework and diverse curriculum models
- Facilitates the development of desirable learning environments and diversified learning

- Generates and advances knowledge in curriculum development through continuous review, research, and evaluation
- Disseminates effective curriculum practices.

In particular, decisions on the mathematics and science curricula are made by staff in the mathematics and science sections of the institute, based on the broad principles set down by the council.

The structure of the education system (a 6-5-2-3 system) in Hong Kong follows the typical British system of 6 years of primary school (G.1 to G.6), 5 years of secondary school (G.7 to G.11, leading to a certificate examination), 2 years of pre-university study (G.12 and G.13, leading to an advanced-level examination), and 3 years of university study. The first 9 years of schooling (primary 1 to secondary 3, or G.1 to G.9) are considered basic education and are compulsory for all children (typically from ages 6 to 15).

Preprimary education includes childcare centers for children ages 2 to 3, and kindergarten for children ages 3 to 6 (K1 to K3). Preprimary education is not part of compulsory education. Kindergartens are privately run, but they need to be registered with the Education Bureau under the Education Ordinance. The *Guide to the Preprimary Curriculum*, developed by the working group formed by members of the Education Bureau and the Social Welfare Department, states that the preprimary curriculum should help foster children's all around development, including the physical, intellectual, language, aesthetic, social, and emotional aspects.[3]

Hong Kong has the following different types of schools: government schools, aided schools, direct subsidy scheme schools, caput schools (private schools), the English Schools Foundation (ESF) schools, local private schools, and international schools.

In the 2001–2002 academic year, there were 777 local primary schools and 38 ESF and international schools.[4] In the 2006–2007 academic year, the number of local primary schools decreased to 620, but the number of ESF and international schools increased to 48. For secondary schools, all types of schools have shown an increase during these 5 years, from 473 local secondary schools and 23 ESF and international schools to 503 local secondary schools and 25 ESF and international schools, respectively.[5]

Students follow the same curriculum up to secondary 3 (G.9), but some schools offer remedial lessons in which low-ability students are grouped together for instruction in mathematics or other subjects. From secondary 4 (G.10) onward, students choose between an arts and a science stream. Some schools offer a commerce stream as well. In secondary 4 and secondary 5 (G.10 and G.11), science-stream students usually take a course called "additional mathematics", as well as the general mathematics course taken by all students. They also may take physics, chemistry, and biology. Some arts-stream students take biology or human biology, and many take geography, which includes earth science. In secondary 6 and secondary 7 (G.12 and G.13), students further specialize in science, arts, or commerce subjects.

Since TIMSS 2003, there have been no recent reforms in the mathematics and science curricula in Hong Kong. As for the structure of the education system, beginning in 2009, it will be changed from a 6-5-2-3 system to a 6-3-3-4 structure (6 years of primary school, 3 years of junior secondary school, 3 years of senior secondary school, and 4 years of university).

Language and Population

Chinese and English are the official languages of Hong Kong. Cantonese is the Chinese dialect used by most of the people in Hong Kong. According to the figures of the 2006 Population By-Census[6] conducted by the Census and Statistics Department, Hong Kong SAR, over 90 percent of children age 5 and over speak Cantonese as their usual language. English (4.4%) and Putonghua (0.9%) are the two other commonly spoken languages in Hong Kong. As far as education is concerned, the government has adopted a biliterate (Chinese and English) and trilingual (Putonghua, Cantonese, and English) policy.

Ninety-five percent of the people in Hong Kong are Chinese.[7] Other ethnic groups constitute about 5 percent of the population. Among these ethnic groups, Filipino (32.9%), Indonesian (25.7%), and White (10.6%) are the three major population subgroups in Hong Kong.[8]

The government issued the *Medium of Instruction Guidance for Secondary Schools* in September 1997.[9] This provides that all secondary schools adopt Chinese to teach all academic subjects (including mathematics and science), beginning with secondary 1 (G.7) in the 1998–1999 school year and adding a grade each year until all levels of secondary education are taught in Chinese, unless a school has obtained approval to use English as the medium of instruction. The number of secondary schools that adopted Chinese as the medium of instruction rose by 223 from 77 to a total of 300 in the 1998–1999 school year. Only 114 schools were allowed to use English as the medium. Secondary schools using Chinese as the medium of instruction for their secondary 1 to secondary 3 classes (G.7 to G.9) may opt to use English for certain subjects in some classes in secondary 4 and secondary 5 (G.10 and G.11). For secondary 6 and secondary 7 (G.12 and G.13), schools may decide on their own what medium to adopt for instruction. Nearly all primary schools in Hong Kong use Chinese as the medium of instruction.

Overarching Policies Related to Education and the Curriculum for Mathematics and Science

In Hong Kong, the school curriculum is divided into four key stages, from key stage 1 to key stage 4. All subjects from primary to secondary levels (G.1 to G.11) follow this structure of key stages. The classification is as follows: key stage 1 (primary 1 to primary 3), key stage 2 (primary 4 to primary 6), key stage 3 (secondary 1 to secondary 3), and key stage 4 (secondary 4 to secondary 5). Thus, at primary 4 (G.4), students would enter the second key stage, and secondary 2 (G.8) students would be in the third key stage of the prescribed curriculum. Learning targets and objectives are organized progressively across the four key stages.

The Mathematics Curriculum in Primary and Lower Secondary Grades

Summary of Curriculum Guides for Mathematics Through Eighth Grade

The Curriculum Development Council has published mathematics curriculum guides, which clearly set forth the goals of primary and secondary mathematics education. The goals of the **primary** mathematics curriculum[10] are the following.

- Stimulate the interest of students in the learning of mathematics
- Develop students' understanding and acquisition of basic mathematical concepts and computational skills
- Develop students' creativity and their ability to think, communicate, and solve problems
- Develop students' number sense and spatial sense and their ability to appreciate patterns and structures of number and shapes
- Enhance students' lifelong learning abilities through basic mathematical knowledge.

The goals of the **secondary** mathematics curriculum[11] are the following.

- Enable students to conceptualize, inquire, reason, and communicate mathematically and use mathematics to formulate and solve problems in daily life, as well as in mathematical contexts
- Enable students to manipulate numbers, symbols, and other mathematical objects
- Develop students' number sense, symbol sense, spatial sense, and a sense of measurement, as well as the capability to appreciate structures and patterns
- Develop students' positive attitudes towards mathematics and the capability to appreciate the aesthetic nature and cultural aspects of mathematics.

The primary mathematics curriculum covers five learning dimensions: number, shape and space, measures, data handling, and algebra.[12] Algebra is introduced to students at key stage 2 but not until students are in primary 5. At key stage 3, less emphasis is put on the number and measures dimensions. The secondary mathematics curriculum integrates the previous five dimensions into four main learning dimensions: number and algebra, measures, shape and space, and data handling.[13] Exhibit 1 summarizes the mathematics topics taught at primary levels. Exhibit 2 details the mathematics topics taught at junior secondary levels.

Exhibit 1 Mathematics Topics Taught at Primary Levels

Primary Levels (Grades 1 to 6, Key Stages 1 and 2)				
Number	**Shape and Space**	**Measures**	**Data Handling**	**Algebra***
Whole numbers Nature of numbers Fractions, decimals, and percentages Calculating devices	Three-dimensional shapes Lines Two-dimensional shapes Angles Directions	Money Length Time Weight Capacity Perimeter Area Volume Speed	Statistics (e.g., simple pictograms, block graphs, bar graphs, etc.)	Algebraic symbols Equations

*Introduced in primary 5 (G.5)

Exhibit 2 Mathematics Topics Taught at Junior Secondary Levels

Junior Secondary Levels (Grades 7 to 9, Key Stage 3)		
Number and Algebra	**Measures, Shape, and Space**	**Data Handling**
Directed numbers and the number line Numerical estimation Approximation and errors Rational and irrational numbers Using percentages Rate and ratio Formulating problems with algebraic language Manipulations of simple polynomials Laws of integral exponents Factorization of simple polynomials Linear equations in one unknown Linear equations in two unknowns Identities Formulas Linear inequalities in one unknown	Estimation in 2-D and 3-D figure measurement Areas and volumes Introduction to geometry Transformation and symmetry Congruence and similarity Angles related to lines and rectilinear figures Introduction to deductive geometry Pythagorean theorem Quadrilaterals Introduction to coordinates Coordinate geometry of straight lines Trigonometric ratios and using trigonometry	Introduction to various stages of statistics Construction and interpretation of simple diagrams and graphs Measures of central tendency Simple idea of probability

The Science Curriculum in Primary and Lower Secondary Grades

Summary of Curriculum Guides for Science Through Eighth Grade

The science curriculum in Hong Kong fulfills the vision of enabling students to attain life-wide and lifelong learning. The goals of the curriculum are to provide learning experiences through which students acquire scientific literacy and develop the necessary scientific knowledge and understanding, process skills, values, and attitudes for their personal development to help them contribute to a scientific and technological world. More specifically, the goals for science education,[14] as described in the *Science Education Key Learning Area Curriculum Guide* (primary 1–secondary 3), are the following.

- Develop curiosity and interest in science

- Develop the ability to inquire and solve problems
- Acquire basic scientific knowledge and concepts for living in and contributing to a scientific and technological world
- Recognize the usefulness and limitations of science and the interconnections between science, technology, and society and develop an attitude of responsible citizenship, including respect for the environment and commitment to the wise use of resources
- Become familiar with the language of science and be equipped with the skills to communicate ideas in science-related contexts
- Appreciate and understand the evolutionary nature of scientific knowledge
- Attain personal growth through studying science
- Be prepared for further studies or entering careers in the scientific and technological fields.

At **primary levels** (key stages 1 and 2), science is part of the subject of general studies. General studies integrates the learning of science education, personal, social and humanities education, and technology education.[15] At **junior secondary levels** (key stage 3), biology, chemistry, physics, earth science, environmental science, and life science are taught in a combined subject, integrated science. All the major science learning elements are arranged in six strands, namely scientific investigation; life and living; the material world; energy and change; the Earth and beyond; and science, technology, and society. Exhibit 3 shows the science topics in each strand in primary levels. Exhibit 4 details the science topics in each strand in junior secondary levels.

Exhibit 3 Science Topics Taught at Primary Levels

Primary Levels (Grades 1 to 6, Key Stages 1 and 2)					
Scientific Investigation	Life and Living Things	The Material World	Energy and Change	The Earth and Beyond	Science, Technology, and Society
Exploring the environment (e.g., visiting the park) Be a scientist (Simple investigations, observations, and interpretations are carried out through the primary science curriculum.)	The body Healthy living habits Characteristics of living things Plants and animals Personal and environmental hygiene Food Growth and reproduction Air	Environmentally friendly practices Conservation of the environment and natural resources Matter	The nature of heat Saving energy Motion Light Sound Electricity	The sun, the moon, and stars Day and night Weather and seasons The Earth Water and the water cycle Light Sound	Reuse and recycle Caring for the environment Wise use of natural resources Our society Hong Kong, China, and the world Information technology in daily life Life and technology Population Problems in the world (e.g., famine, war, and poverty) (The strand on science, technology, and society is applied to most of the science topics in the science curriculum.)

Exhibit 4 Science Topics Taught at Junior Secondary Levels

Junior Secondary Levels (Grades 7 to 9, Key Stage 3)					
Scientific Investigation	Life and Living Things	The Material World	Energy and Change	The Earth and Beyond	Science, Technology, and Society
Introducing science (including lab safety, lab equipment, and conducting experiments) Scientific investigation is carried out throughout the secondary science curriculum.	Plants and animals Cells and human reproduction Living things and air A healthy body Senses	Metals Plastics Matter	Different forms of energy Energy changes Fuels Electricity and circuits	Water, the wonderful solvent Light and colors Space travel Space exploration Forces Gravity	Materials of the modern world Environmental problems of waste disposal (e.g., metal, plastics, etc.) Effects of acid rain on the environment Pollution Acids and alkalis The strand on science, technology, and society is applied to most of the science topics in the science curriculum.

Instruction for Mathematics and Science in Primary and Lower Secondary Grade

Instructional Time

The Education Bureau has guidelines[16] about the number of school days and instructional time. The total number of school days for secondary schools and whole-day primary schools should not be less than 190 days. For bisessional primary schools, the total number of school days should not be less than 209 days. There are about 90 days of school holidays, including major festivals in Hong Kong and several days of other holidays. For example, there is a staff development day during which students do not need to attend classes. Most schools are run on a 5-day school week basis.[17] Students spend an average of about 7 hours a day in school, including lesson time, lunch, recess, assembly, and other activities. Lesson time for primary schools is about 23 hours per week and 27 hours for secondary schools.

Instructional Materials, Equipment, and Laboratories

There are no mandated instructional materials for mathematics and science in Hong Kong. However, there are lists of recommended textbooks and learning materials for different subjects in different grades, starting from kindergarten (preprimary education) to senior secondary levels. These recommended materials have been examined by the appropriate reviewing panels of the Education Bureau's Textbook Committee and are recommended for use in schools.[18] They are considered acceptable in terms of coverage, content, sequence, exercises, language, illustration, and format. Schools can make reference to the bureau's suggestions when selecting textbooks, learning materials, or resource packages, but it is not a compulsory requirement. However, for the most part, schools use textbooks that are on the bureau's suggested list.

Grade at Which Specialist Teachers for Mathematics and Science Are Introduced

Not all the teachers are trained in the subject they are teaching. However, as early as the primary school level, there are teachers specializing in mathematics and science who teach these subjects to students. In secondary schools, teachers who specialize in mathematics and science usually instruct these subjects.

Use of Technology

The appropriate use of information technology (IT) in mathematics learning is emphasized by the Education Bureau. It is pointed out that high technology items, such as computers and calculators, have profoundly changed the world of mathematics education. Students need to master IT to adapt to the dynamically changing environment. With the help of IT tools, meaningless drilling and obsolete topics are no longer essential or relevant in mathematics learning.

In the area of science education, using various IT resources (e.g., multimedia resources) as learning tools also is emphasized. Students are expected to understand the uses and importance of IT in daily life, communicate and handle information with IT tools, access information via the computer and other media (including searching for and selecting relevant information) for a particular purpose, process information with the help of IT tools, be aware of the importance of verifying and evaluating the accuracy and reliability of information, respect intellectual property rights and copyrights, recognize the need for protecting themselves against harmful elements when using the computer (e.g., issues of privacy, health hazards, violence, and pornography), and act appropriately in using IT.

Homework Policies

While there are no official homework policies and the practice differs from school to school, the Curriculum Development Council published a *Basic Education Curriculum Guide,*[19] which encourages "meaningful homework". The guide also gives recommendations on the frequency and amount of homework (for lower primary students, the suggested time for written work in all subjects should not exceed 30 minutes a day and in upper primary, 60 minutes a day) as well as guidance and feedback on homework.

Teachers and Teacher Education

Education and Training for Fourth and Eighth Grade Mathematics and Science Teachers

There are nine institutes in Hong Kong where teacher education programs are offered, although only three of them are considered major providers of teacher education. There are two main types of teacher education programs: a 4-year Bachelor of Education with student intakes from A-Level graduates, and a 1-year full-time (or 2-year part-time) Postgraduate Diploma in Education program with intakes from university graduates. The amount of pedagogical training required in these teacher education programs is not stipulated by the government, and varies from institution to institution.

It is the government's long-term policy to require all new teachers to be professionally trained and hold degrees. The subdegree, preservice teacher training for primary and secondary school teachers, has been progressively upgraded to degree or above levels. Beginning in the 2004–2005 school year, all graduates of preservice primary and secondary teacher education programs are degree holders.[20] However, at the moment, it is still not necessary to have teacher training or teaching qualifications prior to becoming a teacher, but there are restrictions as to what grades or subjects these teachers can teach.

The percentage of primary school teachers who are degree holders has increased to 80.4 percent in the 2006–2007 school year, compared to 49.6 percent in the 2001–2002 school year.[21] Secondary school teachers who are degree holders have increased from 87.9 percent in 2001–2002 to 94.2 percent in 2006–2007.[22] The percentage of primary school teachers who are professionally trained has increased to 94.6 percent in 2006–2007, compared to 90.8 percent in 2001–2002.[23] Secondary school teachers who are professionally trained have increased from 86.6 percent in 2001–2002 to 94.2 percent in 2006–2007.[24]

There are no reported shortages of mathematics and science teachers in Hong Kong. Any person who wishes to teach in a school must be registered with the Education Bureau under the Education Ordinance as either a registered teacher or a permitted teacher. Registered teachers are persons who possess the approved teaching qualifications and/or approved teaching experience laid down in the Education Ordinance, whereas permitted teachers hold only academic qualifications but no teacher training or teacher qualification, and they are given a permit to teach specified subject(s) in specified schools.[25] Private schools offering a nonformal curriculum may have some exemptions subject to their compliance with conditions specified in the Education Ordinance exemption provided for private schools offering nonformal curriculum.

Teacher Professional Development in Mathematics, Science, and Technology

The Education Bureau has a variety of teacher professional development programs for teachers and school heads based on changes in the curriculum, the demand from schools, and other opportunities available in Hong Kong.[26] Teachers may choose to study those programs that are relevant to their needs. Two broad categories of professional development programs are provided.

- Courses to enhance the overall professional knowledge of teachers (e.g., catering to individual differences, motivation, critical thinking skills, curriculum and assessment, gifted education, moral and civic education, Chinese culture, media education, and curriculum management and leadership).
- Key learning areas or subject specific-courses (including mathematics and science) to meet the needs of the new curriculum framework and sustain the curriculum and assessment reform.

There also are a range of collaborative research and development projects on key curriculum changes conducted in partnership with schools and consultants or universities. The school-based curriculum development (primary) section and the school-based curriculum development (secondary) section of the School-based Support

Services provide on-site support to assist schools in strengthening learning in the existing curriculum, promoting curriculum leadership, and developing a school-based curriculum along the lines of the new curriculum framework.[27] Schools and teachers are networked to facilitate the sharing of experiences and the dissemination of good practices through the Regional Education Offices and other means. Moreover, the Advisory Committee on Teacher Education and Qualifications[28] also has offered professional development opportunities for beginning teachers.

The Education Bureau also has programs on technology education in areas of business, accounting and financial studies, design and applied technology, health management and social care, information and communication technology, and technology and living. Target groups are curriculum leaders, panel heads, and teachers of various key learning areas, and sometimes, preservice teachers.[29] New topics are introduced regularly. In 2006, the bureau launched a Technology Education Good Practices Sharing Scheme in secondary schools to recognize the contribution and quality work of school heads, teachers, and students in realizing the aims of education and the goals of the school curriculum through the Technology Education Key Learning Area.[30]

Examinations and Assessments

The Hong Kong Examination and Assessment Authority is responsible for conducting the two major territory-wide examinations in Hong Kong, the Hong Kong Certificate of Education Examination[31] (HKCEE), which takes place after grade 11, and the Hong Kong Advanced Level Examination[32] (HKALE), which takes place after grade 13. These examinations are mainly paper-and-pencil tests, but in the HKALE science subjects, there is a component of school-based assessment[33] where some laboratory work is assessed.

It is the intention of the examination authority that school-based assessment is extended to other subjects and at other levels as well, where students' learning and abilities are assessed by school activities, projects, etc. Certain components of the curriculum cannot be assessed within the context of a written examination, and this can be complemented by school-based assessment. An even more compelling reason for this assessment is that it emphasizes a wide range of student abilities, including the process of learning and growth, thereby strengthening the tie between assessment and teaching and utilizing assessment as a support to teaching. The validity of the assessments therefore is greatly improved. Undoubtedly, teachers are the most suitable people to assess the process of students' learning and growth. School-based assessment also can help reduce the pressure of giving only one high-stakes examination to students and making a judgment based on its result, and affirms the professional judgment of teachers.

Other Tests

The Basic Competency Assessment (BCA)[34] is another territory-wide assessment administered by the examination authority. The BCA has two components, namely, the student assessment and the system assessment, that cover the Chinese language, English language, and mathematics. Basic competencies are the essential knowledge and skills acquired by students in relation to the learning targets and objectives set out in the curriculum for each key stage, and they represent just part of the curriculum requirement. The student assessment is a resource bank provided through the Internet. It is not compulsory and is provided to assist teachers in developing and selecting the appropriate assessment tasks for their students. The system assessment is an assessment administered at the territory level by the government. It is mainly a paper-and-pencil test that is only administered at three levels: primary 3, primary 6, and secondary 3. The system assessment provides feedback to schools about their standards in the three subjects, so that schools can draw up plans to increase effectiveness in learning and teaching. Some schools use commercially developed tests of mathematics and science achievement for their students, but this is not a very common practice.

Monitoring Individual Student Progress

Most schools use grades or marks to report on students' progress.

Grade Promotion and Retention Policies

Promotion and retention policies vary among schools. Most students are promoted automatically to the next higher grade, subject to satisfactory performance and conduct. The Education Bureau has a policy that the retention rate must not be higher than 5 percent.

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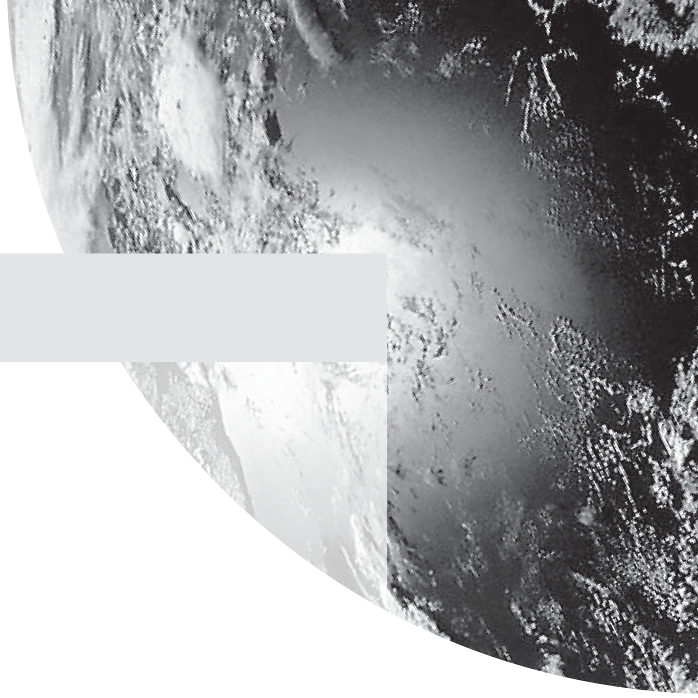

Hungary

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Introduction

Overview of Education System

According to the 1993 Public Education Act LXXIX in Hungary, institutes of public education can be established and maintained by the State, local governments, governments of minorities (regional or nationwide), ecclesiastical legal entities registered in the Republic of Hungary, economic organizations, foundations, associations that were founded and are based in Hungary, and legal entities or native-born individuals acquiring the legal right in accordance with the law. A person also can establish and maintain a public educational institute as a private entrepreneur.[1]

In the education system, administrative responsibilities are shared between the Ministry of Education and Culture and other ministries (primarily the Ministry of Employment and Social Affairs, the Ministry of Finance, and the Ministry of Interior). Administrative control is decentralized, and the managing responsibility is shared among the central (national) and the local (regional) levels of government and the institutional level.

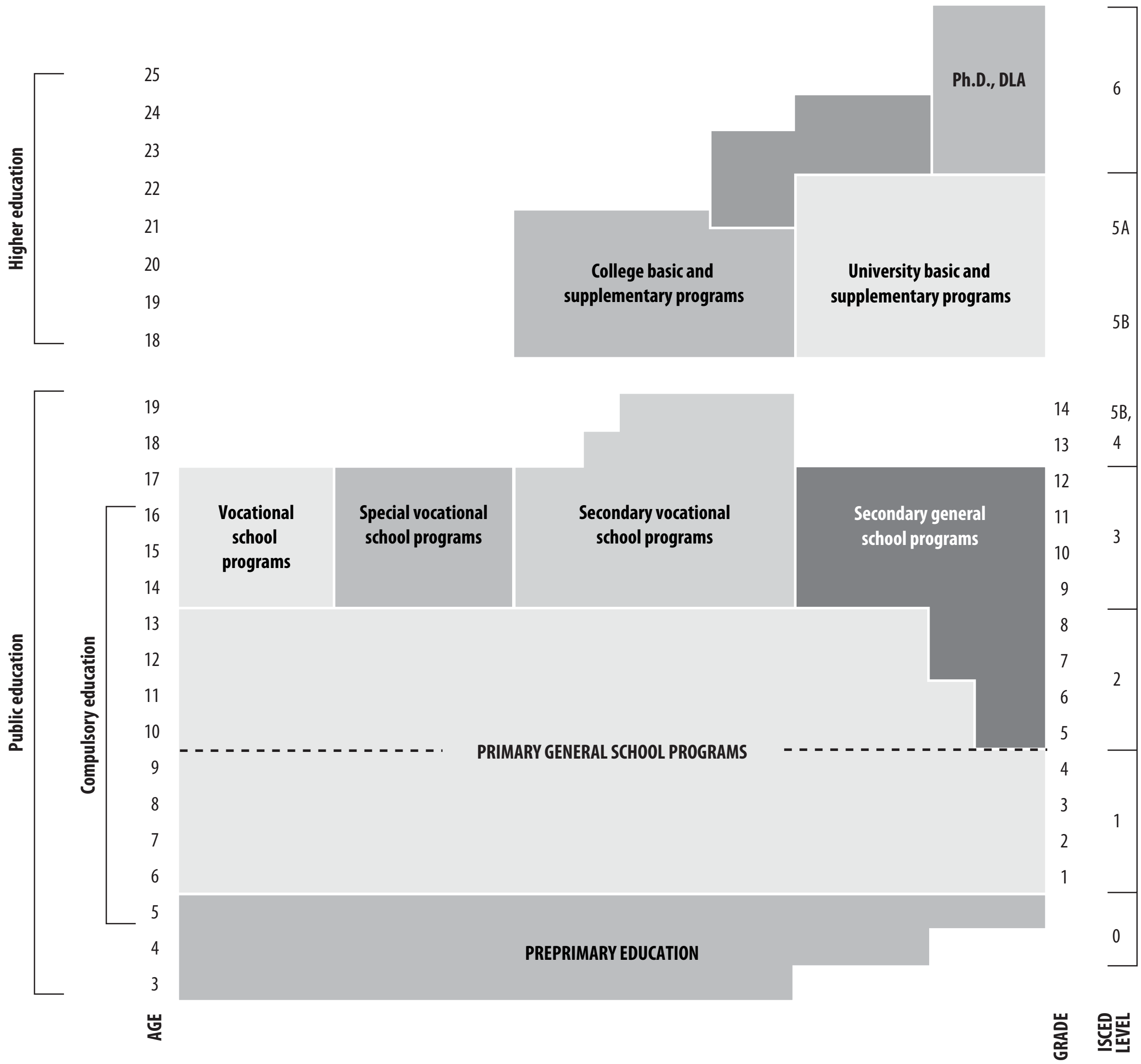
The local governments administer preprimary, primary, and secondary education. The different establishments enjoy a fair degree of decision-making autonomy, not only in terms of organization and functioning but also with regard to their budgets.

Most students attend public-sector schools, which are administered and organized by the public authorities, primarily the local governments. The financing of educational institutions is sector neutral.[2]

A three-level structure, comprised of the National Core Curriculum, the Curriculum Framework, and the local curriculum (the institutional level), provides a regulatory framework for teachers to develop syllabi. Based on a central definition of each discipline, the schools and the local teaching staff can define and adopt the local curriculum and syllabus for each class and each subject. A revised National Core Curriculum was introduced in 2004. This revised curriculum has the special feature of giving priority to the improvement of skills and abilities. Its predecessor, the 1995 National Core Curriculum, applies to those students who participated in the TIMSS 2007 assessment.

Exhibit 1 shows the structure of the Hungarian education system from preprimary school through higher education. The exhibit indicates the typical age of students, associated grades, and length of programs in full-time education.

Exhibit 1 Structure of the Hungarian Public Education System



Beginning in the 1998–1999 academic year, compulsory education is mandated until age 18. Preprimary, primary general, secondary general, and secondary vocational school programs (Exhibit 1) also include programs for students with special education needs. Secondary general school programs include programs for 4 (5), 6, or 8 grades. Special vocational programs are vocational school programs delivered to students with special education needs at ISCED level 2. These programs do not require students to take maturity examinations. Vocational programs also do not require the maturity examination, however, secondary vocational school programs do. Both the vocational and secondary vocational programs include accredited postsecondary vocational programs. There also are college and university basic and supplementary programs. Postgraduate specialization programs, those in ISCED level 5A, have the requirement that students graduate from a college or university with special attainments. These programs do not give a higher attainment level but give a special qualification.

Although the law imposes the provision of free compulsory education, nevertheless, private-sector schools may charge fees. A declaration of school readiness is required for admission to primary school. Schools are obliged to take all acceptable students who live within the area that is served by the school, but parents may seek admission for their children at any institution. Admission to upper secondary schools is based on entrance procedures centrally organized by the Ministry of Education.

Upper secondary schools have the choice to require written entrance examinations. Usually about one third of the upper secondary schools choose to require this centrally organized examination.[3]

There are three different sets of curriculum for secondary general school, secondary vocational school, and vocational school. The requirements of the maturity examination define the exit criteria for secondary general school and secondary vocational school, and the criteria of the given profession(s) define exit requirements for secondary vocational school and vocational school. The vocational school does not end with the maturity examination, therefore it does not provide (without extra years) the possibility of advancing to tertiary education.[4]

Language and Population

The overwhelming majority (over 97%) of the population is Hungarian, and Hungarian is the only official language. The official language of instruction also is Hungarian, but a number of ethnic and national minorities (e.g., German, Romanian, Slovenian, Serbian, and Croatian) have minority educational institutions with their own languages as the first or second language of instruction at the primary and secondary level of teaching. The provision of minority education—similar to mainstream education—is the task of the maintainer, which, in most cases is the local government.[5]

The Mathematics Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Mathematics Through Eighth Grade

Mathematics instruction is regulated by the National Core Curriculum, which includes the goals and tasks, and the Curriculum Framework, containing the actual educational components. The following paragraphs introduce requirements that are summarized in the 1995 National Core Curriculum for the fourth and eighth grades. Some concepts and skills in fourth grade are repeated in eighth grade, adjusted to the level of the age group. For this reason the main topics in mathematics are the same at both levels.[6]

Detailed requirements for **fourth grade** include the following.

- *Grounding cognitive methods:* building relationships between reality and basic mathematical connections through varied mathematical actions, including comparison, grouping, ordering, measurement, constructing, and modeling; ordering according to one or two aspects and increasing awareness in connection with quantity features; representation of mathematical problems; ordering elements in sets that are in different relations and finding the common features; defining features (negation as well); description of sets with statements; and finding the truth set of an open sentence in a given finite set, basic combinatory exercises, ordering some elements, and choosing (by ordering in a chart or diagram).
- *Arithmetic, algebra, sequences, and functions*: natural numbers as the elements of a set or as counting numbers; conscious use of the decimal numeral system, position, and place value; order of magnitude; grounding the concept of the negative number and fractions; operations with natural numbers (written explanation) and the explanation of basic mathematical operations; interpretation and production of mathematical texts and a written interpretation of the appropriate operation to a task accompanied by a text or drawing; and producing and continuing sequences, completing charts in connection with functions, and rule games.
- *Geometry and measuring*: producing geometric shapes by copying or according to given conditions; observing features of simple geometric shapes and the most important features of the square, rectangle, cube, and cuboid; collecting examples of congruent and similar shapes, reflection in two- and three-dimensions, and enlargement and reduction of shapes on grids; and estimation and measurement with given and standard units including length, surface area, weight, cubic capacity, and time.
- *Probability and statistics*: based on games of probability, determine the frequency of random phenomena and illustrate probability; collect, organize, and present statistical data, reading and using data from charts and graphs to practice counting methods.

Detailed requirements for **eighth grade** include the following.

- *Cognitive method:* preparing the mathematical methods of proof including conjectures, experiments, systematic attempts, and proof by contradiction; some unsolved problems in mathematics; interesting facts about the history of mathematics (great mathematicians and the most important mathematicians in Hungarian history); the meaning of expressions such as “and”, “or”, “if”, etc.; the logical connection of concepts and statements; use of terminology appropriate to the age of students and the analysis of mathematical texts with the help of mathematical source materials; subsets, complementary sets, unions, intersections, and subtraction and the solution of varied exercises in combination with different methods; and sequencing, choosing from 4–5 elements.

- *Arithmetic and algebra*: the concept of rational numbers; rounding, operations, and approximate value; operation concepts; exponentiation with a positive integer; concept of square root; ratio and proportion; factorization and resolution into prime factors; primes and simple rules of division; equations, inequalities, base set and solution set, and altering equations and inequalities; simple worded tasks; and substitution values of algebric integer expressions and transferring of expressions.
- *Connections, functions, and sequences*: representations in the Cartesian plane and the relationship between changing quantities; functions and their representation in the Cartesian plane; and examining sequences (simple arithmetic sequences and geometric sequences).
- *Geometry*: units of measurement; regular polygons; right prism, cylinder, pyramid, cone, and sphere; the set of points in the surface that suit the given conditions and geometrical locus; measurement of the circumference, area, surface, and volume; formula for calculating the circumference and area of a circle; surface and volume of a cylinder; construction tasks (60°, 90°, and 45° angles); rotation around a point and translation in two dimensions; line and point symmetry; central similarity; types of angles (pairs of angles); vectors and addition and subtraction of vectors; the Pythagorean theorem; and varied calculating exercises in different topics of geometry.
- *Probability and statistics*: probability experiments; frequency and relative frequency; and collecting and ordering data and representing a dataset.

The Science Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Science Through Eighth Grade

Science instruction is regulated by the National Core Curriculum, which includes the goals and tasks, and the Curriculum Framework, containing the actual educational components. The following paragraphs introduce requirements that are summarized in the 1995 National Core Curriculum for the fourth and eighth grades.[7] In fourth grade, science encompasses integrated natural science, and in eighth grade, the areas include physics, chemistry, biology, and the Earth and environment.

Detailed requirements for fourth grade for **integrated natural sciences** include the following.

- *Methods of cognition*: cognition of simple phenomena of nature, connections, materials, and organisms by action and experience; observation, comparison, grouping, oral expression of the experience, conducting simple experiments, and tracking processes; and sources of knowledge and their usage.
- *Basics of inanimate nature*: observation and measurement of characteristics of different materials (color, shape, temperature, surface, hardness, flexibility, taste, and smell); observation of changes (dissolving, melting, burning, changes of weather, times of the day, seasons, temperature, and the state of matter); the cleanness or pollution of our environment, the most common polluting materials

of soil, water, and air, and recognizing dangerous circumstances; categorization of materials according to their characteristics, usage, and effect; food; examinations with magnets; and flammable and inflammable materials, and combustion.

- *Basics of orientation*: the most important surface forms and water; representation of the relief and hydrogeology on a map; and the points on a compass and their relation to one another.
- *Basics of animate nature*: observation of plants and animals in the environment of students, caring for plants, and examination of the vital environmental conditions of animals and plants; effects of the changing environment and seasonal changes of the flora; wild, bred, and grown living things; difference between animate and inanimate nature; connection between animals and plants, their interdependence, and habitats and their description; and the effect of humans on habitats and the conservation and protection of nature.
- *Human body and its functions*: important features of the body functions of a child (motion, nutrition, and breathing), most common illnesses, personal hygiene, and a healthy lifestyle; harmful health-damaging habits; parts of our body and their functions; the most common, harmful effects of our environment (e.g., sunrays, heat, noise, air, water, soil pollution, and bloodsucker parasites).

In eighth grade, detailed requirements for **physics** are the following.

- *Motion:* linear motion (reference frames, velocity, and inertia); linear accelerating motion and average and instantaneous speed and acceleration; free fall; mass and density; changes in motion; force; representation of force, the effect of two forces, and equilibrium; reciprocal actions, interactions, momentum, and conservation of momentum; different types of forces and their effects; gravity; planetary motion; the gravity of Earth and weight; friction; and resistance.
- *Energy, work, and heat*: types of energy; thermic interaction heat, heat capacity, and heat of combustion; phase transition; changes in energy during phase transition; and conservation of energy and power and energy conversion efficiency.
- *Electricity*: electric current and voltage and their measurement; electric interaction; electric insulators and conductors and sources of electric current or active electronic devices; electronic circuits; electrical resistance and Ohm's law and connections in circuits; effects of an electric current, electrical work and electrical power and their calculation; electric consumption and electromagnetism; and electromagnetic induction and alternating voltage.

In eighth grade, detailed requirements for **chemistry** are the following.

- *Basic concepts, connections, and laws in chemistry:* classification and composition of matters based on their components (element, compound, mixture, and solution); particles in chemistry including atoms, ions, and molecules; the atom, including its composition, models, and subatomic particles; chemical symbols, the periodic table, and chemical formula; chemical change, reaction types, and chemical equations; quantitative knowledge and the amount of substance and the law of conservation of mass and matter; solutions and their concentration; occurrence, preparation and production, usage, and typical reactions of substances and observation of their physiological and environmental effects; and non-metal elements and compounds and metal elements and their compounds.

- *Applications of matters:* matters that are important in practical everyday life, their usage, and methods; the composition of air and natural water and the most common polluting matters; raw matters and energy resources, and nutriment as raw matter and energy resources; household chemicals; metal alloys, corrosion, and the prevention of corrosion; and some inorganic chemical procedures including metallurgy, sulphuric acid production, and glass production.

In eighth grade, detailed requirements for **biology and hygiene** are the following.

- *Landscapes and biomes*: organisms that construct the different food chains of different landscapes; the effect of pollution on living things and food chains; and cultivated plants.
- *Human body and health*: parts of the human body, organ systems (sensory, skeletal, muscular, digestive, respiratory, circulatory, secretory, reproductive, and regulatory systems), and fibers; illnesses of the organ systems; characteristics of human body cells; and phases of growth and development, characteristics of phases, and the most common health problems.

In eighth grade, detailed requirements for **our Earth and environment** are the following.

- *Our Earth and environment*: the Earth and the solar system; the Earth as an astronomical object, its formation, shape, and movements; chronology; our cosmic environment, the solar system and its connections to the Earth (solar and lunar eclipse, and tides), and formation of galaxies and stars, their development, and artificial satellites; and space research.
- *Basics of geology*: matters that form the Earth; mineral and rock formation; fossil remains; the formation and the structure of the Earth; plate tectonics; basins, continents, mountains, earthquakes, and the development of volcanoes; and the history of Earth.
- *The hydrosphere*: mainland waters, oceans, and seas; and water management and protection.
- *The atmosphere*: the composition of the atmosphere, its structure, and its basic processes; types of winds, their effect on the weather, and climate; and global warming, the greenhouse effect, climate, and climate change.
- *Formation of landscapes*: natural processes that form landscapes and the effect of human activity, and the formation of typical landscape forms and their characteristics.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Time

The school year comprises 185 days of teaching, starting some time between the end of August to the beginning of September. There are three school breaks (each approximately 1 week) in autumn, winter, and spring, and there is an additional 10–11 week break during the summer. There are 5 days of school every week. Teaching lessons usually last 45 minutes. The law stipulates the maximum numbers of teaching lessons for grades 1 to 8 in mathematics and science based on the Curriculum Framework.[8, 9]

- **Mathematics**. In grades 1 and 2 and grade 5, there are 148 lessons per school year in each grade. In grade 3, there are 130 lessons. In grade 4 and grades 6–8, there are 111 lessons per school year in each grade.
- **Science**. Integrated natural sciences includes environmental studies and natural studies. In environmental studies, there are 37 lessons in grades 1 and 2, 55 lessons in grade 3, and 74 lessons in grade 4 per year. There also are 74 lessons per year for nature studies in grades 5 and 6. In grades 7 and 8, students receive 55–56 lessons in physics, biology, chemistry, and in our Earth and environment per year.

Instructional Materials, Equipment, and Laboratories

The choice of textbooks used for learning is the responsibility of the teaching staff. However, the Ministry of Education approves the list of eligible textbooks. Schools and teachers can choose from a wide range of textbooks. In the Curriculum Framework, there are professional recommendations for each subject about devices and materials that help students acquire knowledge and develop skills.[10]

Grade at Which Specialist Teachers for Mathematics and Science Are Introduced

In elementary schools in Hungary, one teacher teaches all subjects to the students and works with them until the end of grade 4. In grades 5 and 6, primary or secondary school teachers have qualifications in the given subjects. In grades 7 and 8, qualifications and professional training are required in the given subject.[11]

Use of Technology

The Curriculum Framework for mathematics formulates the goals and tasks that are important for that subject in regards to technology. Students learn the practical use of electronic devices (calculators, graphic calculator, computer, the Internet, etc., depending on their availability), as well as of data storage devices in gaining information and simplifying problem solving. The new, modified National Core Curriculum, introduced in 2004, includes the use of computer and multimedia devices beginning in the seventh grade in the area of natural sciences. In mathematics, technology is used before grade 7.

Teachers and Teacher Education

Education and Training for Fourth and Eighth Grade Mathematics and Science Teachers

According to the Public Education Act, those who have the appropriate qualifications and professional training in tertiary education (a university or college level degree) can be employed as teachers in an educational, pedagogical institute.

The teacher training colleges (eight semesters) train professional teachers for grades 1–4 in all subjects, and for grades 5 and 6 in their specialized field or subject. Options in the compulsory fields include Hungarian language and literature, foreign languages, mathematics, humans and society, humans and nature, music, visual training, information technology, life management and technology in the household, and physical education and sport.

Students that attend the teacher training courses have to take part in professional practice. The professional training helps the development of special teaching skills, techniques, and proficiency. The professional practice includes observations of lessons, team or individual practice in schools, and practice in pedagogical and methodological studies. In the last semester, students take part in an 8–10 week teaching practicum.

For current teachers, teacher training both at the college and the university level consisted of two parts carried out at the same time: basic education in the different areas of specialty, as well as uniform teacher training. Beginning in 2006, teacher qualifications will be obtained at the master's degree level for teaching in grades 5–12. In the new system of teacher training, there are two separate cycles. In the first cycle, prospective teachers gain the basics of their special subjects and develop their academic skills. The second cycle of the training focuses on the pedagogical areas.[12] Teachers of TIMSS 2007 students obtained their qualifications in the former teacher training system.

Teacher Professional Development in Mathematics, Science, and Technology

The Public Education Act requires all teachers to participate in regular professional development. Schools must create an education plan every 5 years that includes professional development, and teachers can apply for courses listed in these plans. Teachers are required to take at least 120 hours of professional development courses every 7 years. Teachers who participate in the training receive a financial reward, while those who do not risk losing their jobs.

If a teacher attends these courses, the number of classes he or she is responsible for can be reduced. Furthermore, the employer may cover the total costs of training. Generally, the school covers 80 percent of training costs. Coverage of the additional costs (e.g., travel and accommodations) is different in each case.

Subject examination preparatory courses have the highest rank in teacher professional development. These usually are education management, pedagogical, and professional services courses. However, assessment and evaluation courses also are becoming more popular. After completing a subject examination preparatory course, teachers advance a step on the pay grade, can request to be included in the national listing of experts, and can undertake specialized public education tasks.

Examinations and Assessments

National or Regional Examinations

The arrangements for student assessment are identical to those in primary education. At the end of upper secondary courses in Secondary General School and Secondary Vocational School, students take the national secondary school-leaving examination (maturity examination). This certificate is a prerequisite for admission to higher education. Vocational schools also may award a vocational qualifying certificate.

Since the 2001–2002 school year, Hungary has administered its National Assessment of Basic Competencies seven times to examine student performance in mathematics and reading. Since 2004, all students in grades 6, 8, and 10 take part in the testing. The assessment measures whether students can use their skills and knowledge to solve everyday situations and does not focus on textbook knowledge. The assessment benchmarks student performance in four levels of competency. Schools, and the organizations responsible for them, receive a report and data analysis software that enables them to study their students' performance and locate their school on these benchmarks. Parallel to this study, the testing of fourth grade students' basic reading, mathematics, problem solving, and writing skills began in the 2005–2006 school year. The Public Education Act guarantees the annual administration of these tests. The same law requires that schools observe the performance of their school as part of their quality-control programs.

Mandatory testing of crucial basic competencies started in the first grade of elementary school in the 2006–2007 school year in order to reduce the disadvantages caused by the differential developmental rate of students. The Ministry of Education provides an evaluating kit, called the Diagnostic Development System, without a fee to all institutes.

Monitoring Individual Student Progress

The performance and progress of students is regularly evaluated through grading. Teachers use these grades to form midterm and end-of-term grades. The head teacher notes a grade for the student's conduct and diligence after consulting with the other teachers also working with that student.

The school informs parents about student performance on a regular basis. Students keep a booklet with their grades and school notices that parents and their head teacher sign every month. Additionally, the school sends notices to parents via the students at the midterm and the end of the school year.

Grading is as follows in higher elementary and secondary education: excellent, 5; good, 4; mediocre, 3; sufficient, 2; and insufficient, 1. When evaluating conduct and diligence, 5 refers to exemplary and 2 to bad (insufficient cannot be given).

In grades 1–3 and at the midterm in grade 4, teachers have to present a written evaluation of whether the student's progress is excellent, good, adequate, or if the student requires tutoring. Additionally, teachers must give a detailed evaluation of the student's speech, oral expressiveness, and performance on the basic domains of culture and the student's attitudes.

Grade Promotion and Retention Policies

In grade 1, students having difficulty do not have to repeat the year. It is possible to make the student repeat a year at each grade during the next 3 years, but only with the consent of the parent. A numeric mark is not provided.[13]

Suggested Readings

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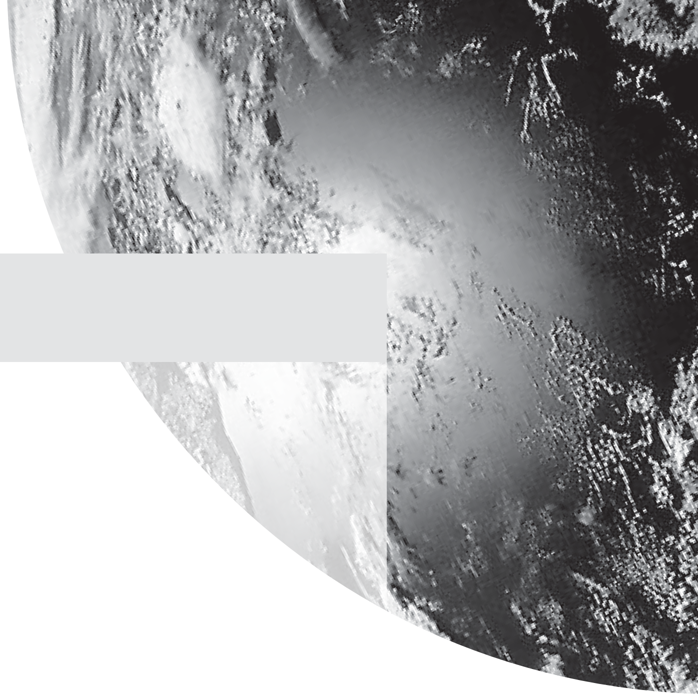

Indonesia

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Introduction

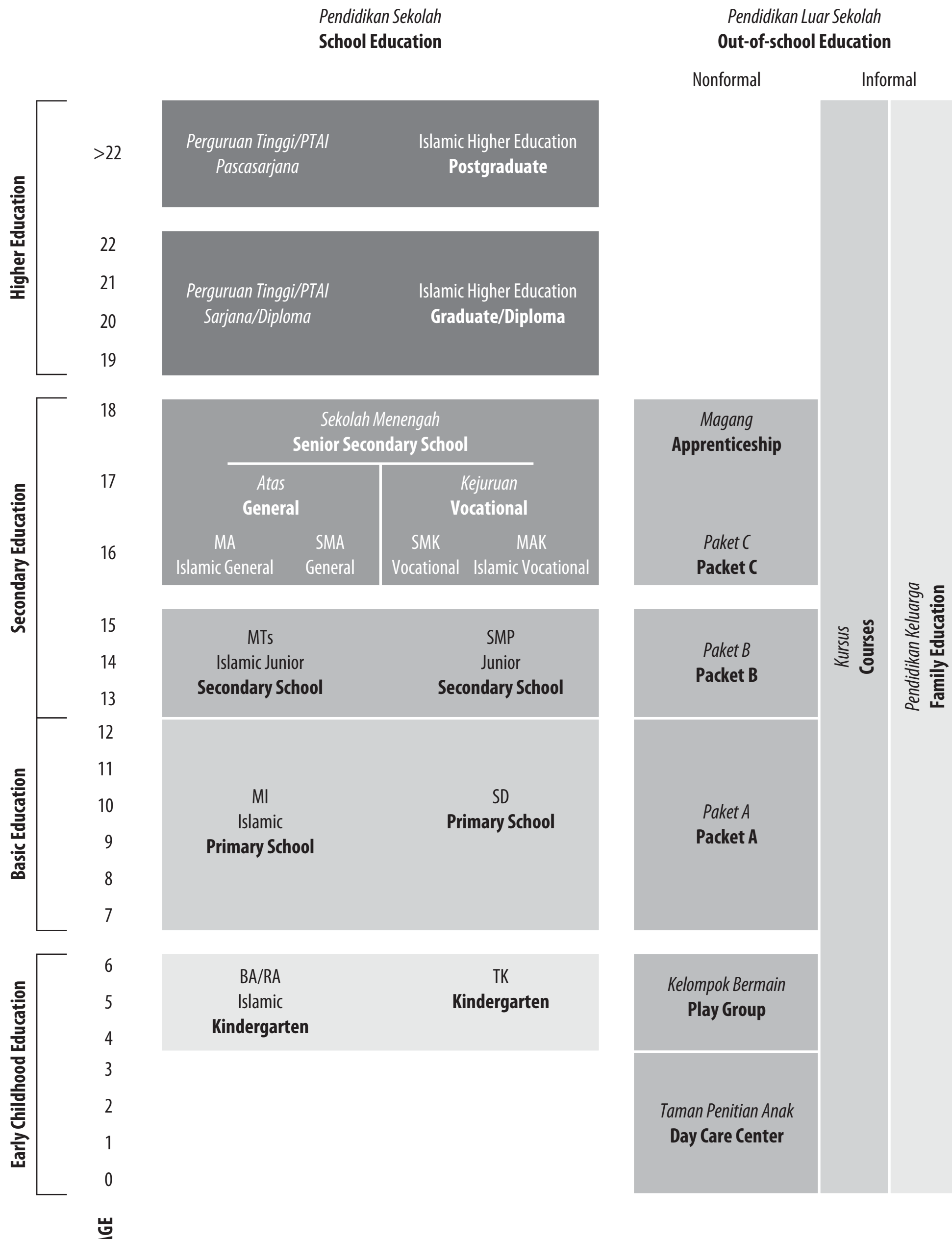
Overview of Education System

National education in Indonesia is based on Pancasila, which is the philosophical foundation of the Indonesian state and was set forth in the 1945 Constitution of the Republic of Indonesia in Law Number 20, year 2003.[1] The goal of the national education is to develop the capability, character, and civilization of the nation by enhancing its intellectual capacity and developing learners' potentials so that they are instilled with human values; are faithful and pious to one and only one God; process morals and noble character; are healthy, knowledgeable, competent, creative, and independent; and are democratic and responsible citizens.

In 2006, the Ministry of National Education introduced a significant change to the Indonesian education system by shifting from a centralized to a decentralized curriculum that includes content standards, as well as standard and basic competencies. Each governorate is now responsible for implementing the national curriculum, which was released officially by the Curriculum Center. Now, each school must develop curriculum guidelines for every subject that are consistent with a school-based management concept by using a system of committees that include consultants, supervisors, experts, education professors, and experienced teachers. The curriculum for mathematics and science is developed by mathematics and science teachers, using the national content standards as a reference. To be sure that the national content standards are upheld, the Board for National Standards in Education and the Textbooks Evaluation Center coordinates an evaluation of selected textbooks by supervisors, experts, education professors, and experienced teachers. During the transition to the new education system, the 2004 national curriculum still is being used. This curriculum includes a single textbook used nationwide in each subject in each grade.

In Indonesia, education is structured in streams consisting of formal, nonformal, and informal education[2] (see Exhibit 1).

Exhibit 1 Formal, Nonformal, and Informal Education in Indonesia, Law No. 20, 2003



Source: Indonesia Ministry of National Education. (n.d.). *Indonesia educational statistics in brief 2005–2006*. Jakarta: Author.

Formal education[3] includes three levels: basic, secondary, and higher education (see Exhibit 2). It also has various types of education including general, vocational, professional, vocational and technical, religious, and special education. Each type of education complements and enriches the others. Education is provided through face-to-face and/or distance learning. The streams, levels, and types of education are educational units organized by the national government, local government, and/or the community.

Basic education is the foundation for secondary education. It takes place in primary schools, such as *Sekolah Dasar* (*SD*), *Madrasah Ibtidaiyah* (*MI*), or other schools of the same level, and in junior secondary schools, such as *Sekolah Menengah Pertama* (*SMP*), *Madrasah Tsanawiyah* (*MT*), or other schools of this level.

Secondary education is the continuation of basic education. Secondary education comprises general secondary education and vocational secondary education. It takes place in senior general secondary schools, such as *Sekolah Menengah Atas* (*SMA*) and *Madrasah Aliyah* (*MA*), and senior vocational secondary schools, such as *Sekolah Menengah Kejuruan* (*SMK*), *Madrasah Aliyah Kejuruan* (*MAK*), or other schools of this level.

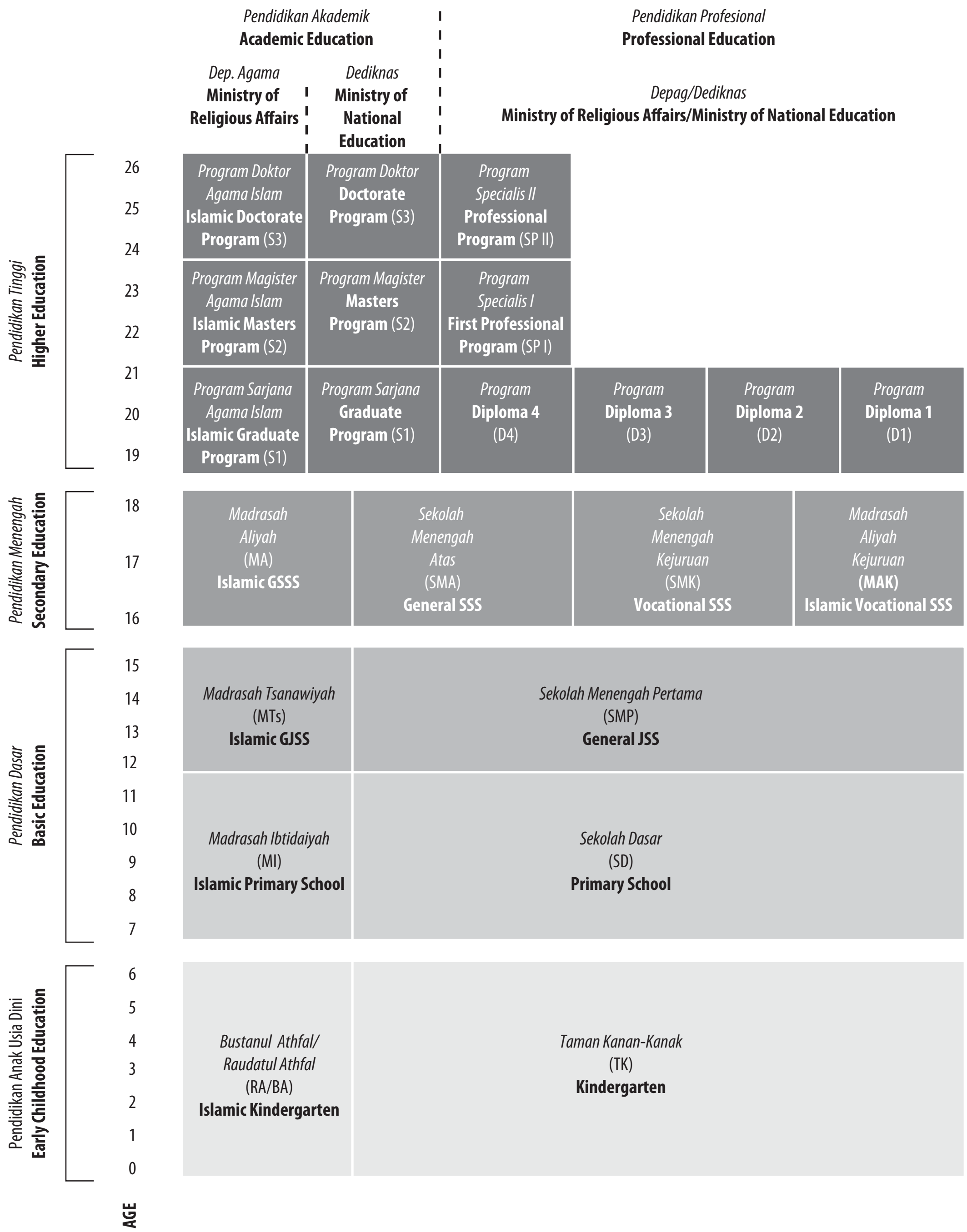
Higher education is the level of education after secondary education. Students in higher education obtain a bachelor's (*sarjana*), master's, or specialized postgraduate and doctorate degrees. Higher education institutions can be an academy, polytechnic, college for specialization (*sekolah tinggi*), institute, or university. Higher education institutions provide education, research, and community services and offer academic, professional, and/or vocational and technical programs.

Nonformal education is provided for community members as a replacement, complement, and/or supplement to formal education to support lifelong learning.[4] Nonformal education aims to develop learners' potential with an emphasis on the acquisition of knowledge and functional skills and personal and professional attitudes. Nonformal education includes life skills; early childhood, youth, women empowerment, and literacy education; vocational training and internships; equivalency programs; and other kinds of education aimed at developing learners' abilities.

Informal education is provided by families and communities in place of formal education. Upon completion of informal education, students can try to pass an assessment measuring the national education standards. If students are successful, informal education is recognized as equivalent to formal and nonformal education.

Early childhood education is provided prior to basic education in all streams of education (formal, nonformal, and informal education). In formal education, early childhood education can be found in kindergarten, *Taman Kanak-Kanak* (*TK*), *Bustanul Athfal* (*BA*)/*Raudatul Athfal* (*RA*), or other similar forms of formal education. In nonformal education, early childhood education takes the form of play groups, *Kelompok Bermain* (*KB*); child care centers, *Taman Penitipan Anak* (*TPA*); or other similar forms of nonformal education. In informal education, early childhood education takes the form of family education or education in the community.

Exhibit 2 Formal Education System in Indonesia, Law No. 20, 2003



Source: Indonesia Ministry of National Education. (n.d.). *Indonesia educational statistics in brief 2005–2006*. Jakarta: Author.

Language and Population

Bahasa Indonesia is the official language of Indonesia and the language of instruction. There are over 700 regional languages in Indonesia, such as Minangkabau, Acehenese, and Javanese. In some international schools (for children of diplomats) and Islamic schools, English and Arabic are common languages. English is taught starting in grade 7.

There are many population subgroups based on either language or ethnic group. The two biggest subgroups are Javanese and Sumatran.

Second-language Instruction

Although Bahasa Indonesia is the primary language of instruction in schools, primary teachers in some districts provide mixed instruction in Bahasa Indonesia and the children's mother-tongue language.

The Mathematics Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Mathematics Through Eighth Grade

According to the national mathematics curriculum, students should have been taught each of the following topics or skills by the **end of grade 8**.[5]

Number:

- *Whole numbers*: refers to place value, factorization, the four operations, computations, estimations, and approximations.
- *Fractions and decimals*: refers to common fractions, including equivalent fractions and ordering of fractions and decimals, such as place value, ordering, converting to common fractions and vice versa; representing decimals and fractions using words, numbers, or models (including number lines); and computations using the four operations with fractions, decimals, and percents.
- *Integers*: refers to representing, comparing, ordering, and computing with integers.
- *Ratios, proportions, percents*: includes equivalence, division of a quantity by a given ratio, conversion of percents to fractions or decimals, and vice versa.

Algebra:

- *Patterns*: extend numeric, algebraic, or geometric pattern or sequences using words, symbols, or diagrams and find missing terms and generalize pattern relationships in a sequence or between adjacent terms or between the number of the term and the term using words or symbols.
- *Algebraic expressions*: includes sums, products, and powers of expressions containing variables.
- *Equations and formulas*: refers to solving problems using equations or formulas.

Geometry:

- *Lines and angles*: includes identifying angles (acute, right, straight, obtuse, and reflex); and knowing and using the properties of angle bisectors and perpendicular bisectors of lines.
- *Two- and three-dimensional shapes*: refers to identifying properties of geometric shapes (triangles, quadrilaterals, and other common polygons); applying geometric properties to solve routine and nonroutine problems; and calculating the length of lines, surface areas, or volumes of shapes such as cubes and squares.
- *Congruence and similarity*: includes identifying shapes' similarities.
- *Symmetry and transformations*: refers to identifying transformation results from points to shapes (translation, movement, rotation, and reflection).

Data management (in primary school) or **statistics and probability** (in secondary school):

- *Data collection and organization*: refers to calculating and displaying mean, median, range, and shape of distributions (in general terms); and determining sample sizes for random experiments.
- *Data representation*: includes constructing tables, pictographs, bar graphs, pie charts, and line graphs.
- *Data interpretation*: refers to interpreting data sets by drawing conclusions, making predictions, and estimating values between and beyond given data points.
- *Uncertainty and probability*: refers to judging the probability of an event.

The Science Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Science Through Eighth Grade

According to the 2006 national content standard of science, students should have been taught each of the following topics or skills by the **end of grade 9**.[6]

- *Biology topics (including environmental science) learned by the end of grade 8 include*: characteristics and classification of living organisms; variety in the stucture of living organisms; ecosystem; biodiversity; ecosystem conservation; human population; pollution; growth and development of living organisms; human development; health; movement, digestion, respiratory, and circulatory systems in humans; the structure and function of plant tissues; photosynthesis; nutrients; movement in plants; and plant diseases.
- In addition, *topics to be learned by the end of grade 9 include*: excretion and reproduction system in humans; coordinatory system and senses in humans; adaptation, selection, and reproduction of living organisms; heredity in living organisms; biotechnology in nutrient production.
- *Chemistry topics learned by the end of grade 8 include*: properties of acids, bases, and salts; elements and simple formulas of chemistry; characteristics of elements, compounds, and mixtures; atoms, ions, and molecules; and effects of using chemical substances in daily life.
- *Physics topics learned by the end of grade 9 include*: measurement; scales and units; matter and density; physical and chemical changes; motion, force, and energy; vibrations and waves; optics; electricity; magnetism; solar system; sound and light; and electric energy.
- *Earth science (part of social science) topics learned by the end of grade 9 include*: Earth's structure, process, cycles, history, and physical features (lithosphere, hydrosphere, and atmosphere); Earth in the solar system and the universe; and using a map, atlas, and globe.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Time

Mathematics is introduced into the first primary grade as a single subject. Science begins in the first primary grade using a thematic approach. In a typical week, the total amount of instructional time for mathematics is 3 hours and 45 minutes, and for science, it is 3 hours.

Instructional Materials, Equipment, and Laboratories

Instructional materials are used to enrich and explain the curriculum, including activities that involve active learning. Some schools are well resourced with the essential equipment and laboratories.

Grade at Which Specialist Teachers for Mathematics and Science Are Introduced

Generally, in primary grades 1 through 6, teachers are responsible for instruction in all subjects. However, for some schools, beginning in grade 4, there are teachers who specialize in mathematics and science.

Use of Technology

Teaching computer skills is mandated for grade 7. Some schools are well equipped with computer labs and multimedia centers. Mathematics and science teachers benefit from using this new technology.

Homework Policies

There are no homework policies, but it is recommended that teachers give homework in grade 8.

Teachers and Teacher Education

Education and Training for Fourth and Eighth Grade Mathematics and Science Teachers

Teachers for grades 7 and up must complete a 4- or 5-year university program with pedagogical training in a specific subject or a specialization in education. During their university study in the Education Department, mathematics and science teachers spend about 60 percent of their time studying mathematics or science, while the other 40 percent is devoted to studying pedagogy. Teachers for grades 1 to 6 (primary school) are required to have certificate D-2 (i.e., a 2-year diploma). However, with the new rules in 2006 for teacher education, teachers are required to complete university and have a teaching certification. According to the new requirements, the Ministry of National Education provides scholarships and professional development in all subject areas. In addition to their academic and pedagogical studies, perspective teachers must have had experience teaching in schools.

Indonesia does not have enough qualified teachers outside of Java Island, especially in the rural areas. Therefore, in some cases, teachers are not teaching the subjects in which they were trained. Most good teachers prefer to work on Java Island.

Teacher Professional Development in Mathematics, Science, and Technology

The Indonesian Quality Assurance Institute offers mathematics, physics, and biology teachers a number of professional development activities and training opportunities, including innovative approaches to teaching mathematics, physics, and biology using technology and improving classroom assessments in these subjects as well.

Examinations and Assessments

National or Regional Examinations

Students take national and regional examinations throughout their formal schooling. In grades 7 through 12, there is a formative or summative regional examination every semester. The purpose of the formative examinations is to monitor learning, while the summative examinations determine whether or not a student is promoted to the next grade. In addition, there is a national high-stakes examination at the end of grades 6, 9, and 12.[7] The subjects tested in grade 6 are mathematics, Bahasa Indonesia, and science. The subjects tested in grade 9 are mathematics, Bahasa Indonesia, English, and science. The subjects tested in grade 12 are mathematics, Bahasa Indonesia, English, science, and social science. The purpose of the national examination is to provide certificates to students who pass. The pass-fail decision is based on the results from the national examination, in addition to the results from some subject matter examinations conducted by the district. Passing the national examination is required for students who want to continue to the university program or higher education program.

Monitoring Individual Student Progress

Teachers and schools monitor the progress of individual students through marks and report books. Students receive report books for each term with marks for each subject. Periodically, parents receive school reports of their child's progress to be signed and returned to the school. This allows parents to follow their child's progress and take action when low achievement is reported. Remedial programs are offered under school supervision.

Grade Promotion and Retention Policies

In addition to the high-stakes examination described previously, in grades 1 through 11, examinations for promotion are conducted by schools at the end of each term (in December for the first term and in June for the second term). Failing the examinations can result in the student having to repeat the entire academic year.

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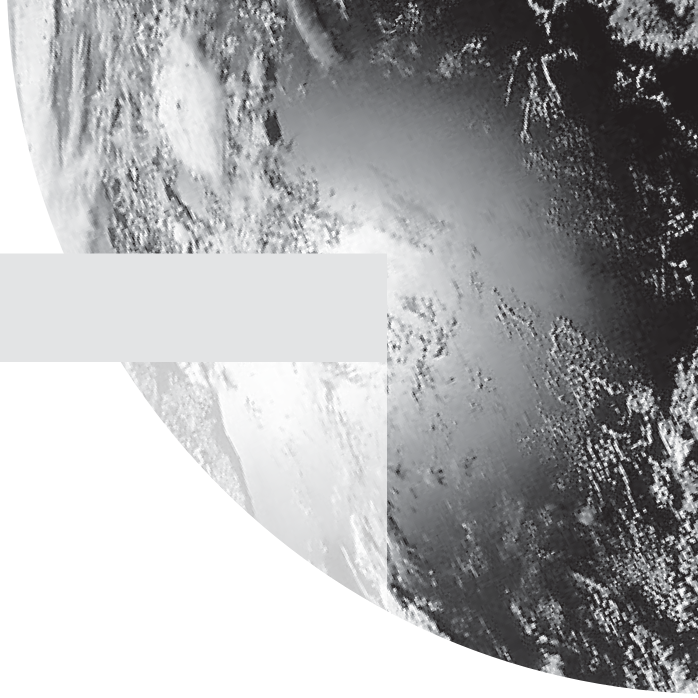

Islamic Republic of Iran

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Introduction

Overview of Education System

The Constitution of the Islamic Republic of Iran is inspired by Islamic principles and precepts, and it attributes great importance to education.[1] According to Article 3 of the Constitution, the government is responsible for providing free education and strengthening the spirit of inquiry and investigation in all areas of science, technology, culture, and Islamic studies up to secondary school. Regarding religious education, Christians, Jews, and Zoroastrians are free to teach and perform their religious rites and acts according to their own canons in matters of personal affairs and religious education.

The Ministry of Education administers and finances schools at the primary and secondary levels while the Supreme Educational Council, an autonomous and legislative body, approves all policies and regulations related to formal, pre-university education. The Ministry of Science, Research, and Technology is responsible for nonmedical degree universities. The Ministry of Health and Medical Education deals with education at medical schools and paramedical degrees. The Ministry of Labor and Social Affairs is responsible for nonformal vocational trainings.

The structure of education up to the pre-university level is highly centralized. At the pre-university level, the goals of education are set according to Islamic principles by the Higher Council of Education. The Ministry of Education is composed of several deputy ministries. Each has specific responsibilities such as developing and planning educational goals, conducting and supervising educational activities, devising curriculum, compiling textbooks and other educational materials, publishing and distributing educational materials, planning and conducting workshops and providing for teacher professional development, making policies, and defining priorities regarding human resources within the Ministry of Education.

The formal education system in Iran consists of 1 year of preprimary education, which children begin when they are 5 years old, followed by 5 years of primary education. When children are 11, they begin 3 years of lower secondary education, which leads to 3 years of upper secondary education and 1 year of pre-university.

During the **preprimary year**, children are prepared for the formal primary stage. The Organization for Educational Research and Planning is responsible for supervising and preparing the education at preschool centers. Though the preprimary stage is not mandatory for all children, it is required in bilingual areas of the country where Farsi is not the children's mother tongue. In these cases, Farsi is taught to children in addition to regular preprimary activities. The main objectives of this stage are as follows.

- Contribute to the physical, mental, emotional, and social growth of children
- Develop children's abilities and talents
- Prepare children to comprehend scientific concepts
- Promote the Farsi language
- Prepare children for social relationships and cooperation.

Primary education is the first stage of formal education. It lasts 5 years and caters to students, ages 6–10. The main objectives of this stage are as follows.

- Create an atmosphere for the moral and religious development of students
- Enable students to read and write, improve their mathematics and literacy skills, and provide necessary training on proper social behavior
- Instruct students on individual hygiene and provide necessary advice on how to behave at home, as well as in society
- Develop students' talents and abilities and physical strength.

The **lower secondary (guidance) education** stage is 3 years and is for children 11–13 years old. At this stage, students become familiar with various subjects in the experimental and social sciences, as well as humanities and art. The main goals of this stage are as follows.

- Develop students' moral and intellectual abilities
- Increase students' experiences and general knowledge
- Strengthen the habits of discipline and scientific imagination among students
- Identify individual preferences and talents in students in order to direct them towards a suitable study program.

Upper secondary education consists of 3 years of formal schooling for students, ages 14–16. The first grade in this stage is the same for all programs of study. In the second year, students choose among academic, technical, and vocational or *Kar-Danesh* training programs. Students enter different programs according to their capabilities and interest. The curriculum of the upper secondary stage consists of three types of subjects and courses: general or common subjects that are common for all programs of study, elective subjects, and specialized subjects that are specific for each branch. At the end of this stage, there is a final examination administered nationwide.

Pre-university is a 1 year education program for high school graduates who would like to participate in university entrance examinations in order to further their education.

Language and Population

The Islamic Republic of Iran is a country situated in south Asia. According to the 2007 census, the population of Iran is about 67.7 million with an approximate literacy rate of 77 percent.[2] Persian, Turk, Kurd, Lori, and Arab populations are some of ethnic groups living in Iran. About 67 percent of the population lives in urban areas, and the rest live in rural areas. Approximately, 99.6 percent of the population is Muslim, 0.13 percent is Christian, 0.02 percent is Jewish, 0.04 percent is Zoroastrian, and the rest observe other religions.[3] Christians, Jews, and Zoroastrians have their own representatives in the Islamic Consultative Assembly.

Iran's official language and also the language of instruction is Farsi (Persian), and all textbooks are in Farsi. There are other languages spoken in some parts of the country that reflect ethnic groups, such as Turkish, Arabic, Kurdish, and Lori, but they are not official languages of the country. However, the use of tribal and local languages in local press, mass media, and teaching about their heritage is permitted.

Emphasis on Mathematics and Science

As a result of participation in TIMSS and observing students' performance, there has been a considerable emphasis on mathematics and science education in Iran, which has led to the current program of study.

Overarching Policies Related to Education and the Curriculum for Mathematics and Science

As mentioned above, the Ministry of Education is responsible for providing the standards and principles of mathematics and science education, as well as curriculum outlines and compilation of textbooks.

Since 2004, the mathematics department in the Curriculum Development Center has been working towards preparing the National Mathematics Curriculum, instead of the previous policy of providing the curriculum through subject guides for each textbook at different levels. The recommended approach to teaching and learning is problem solving and participation of students in class and group activities. The current National Science Curriculum for the primary level was introduced in 1994 and for middle school in 2000.

The Mathematics Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Mathematics Through Eighth Grade

The ministry's guidelines for mathematics[4] emphasize the following areas: content domain, mathematical processes, and general skills.

Content domain means that students should become familiar with the basic and necessary facts and concepts in mathematics.

Mathematical processes refers to the focus of the curriculum on mathematical processes, including problem solving, modeling simple real-life situations, making conjectures and evaluating them, estimating, and reasoning.

General skills are critical and creative thinking, observation, abstraction and generalization, comparing and ordering, and classifying and sorting.

By the end of **fourth grade**, students have learned the following.

- *Numbers and operations:* whole numbers and representing whole numbers; estimation and computation with whole numbers; place values; the meaning of fractions and equivalent fractions; comparing and ordering fractions; operations with fractions such as adding and subtracting; decimals and addition and subtraction with decimals; number patterns and extending patterns; and modeling simple situations.
- *Geometry and measurement:* metric units in measurement; measuring angles; length; area of common two-dimensional shapes; parallel lines; comparing angles by their size; properties of common geometric shapes; calculating perimeter and area of parallelograms, rectangles, triangles, and squares of given dimensions; and symmetry and figures with line symmetry.
- *Data handling:* pictographs and simple block diagrams.

By the end of **eighth grade** students have learned the following.

- *Number and operations:* multiplication and division of fractions and decimals; the conversion of fractions to decimals and vice versa; the meaning of integers and computation with integers, ratio, proportion, and percent; the meaning of mixed numbers, the addition and subtraction of mixed numbers and multiplying mixed numbers by a whole number; and exponents and the square root of numbers.
- *Geometry and Measurement:* types and relationships of angles; angles associated with the transversal cutting of parallel lines; perpendicular lines; the type of and congruency of triangles; constructing congruent triangles; similar triangles and their properties; the Pythagorean theorem; three-dimensional shapes and their relationship to two-dimensional shapes; the surface area and volume of a cylinder; rectangular cubes, spheres, and pyramids; a circle and a tangent line to a point on a circle and angles in a circle; circumference and the area of a circle; the measure of irregular compound areas by dissecting pieces; Cartesian planes, intersections, and gradients; lines and rotational symmetry; and transformations.
- *Algebra:* expressions; sums, products, and powers of algebraic expressions; simplifying algebraic expressions and evaluating algebraic expressions for given values; linear equations, slope, and the simultaneous system of equations (two equations with two variables); and ordered pairs and coordinate systems.
- *Probability and data handling:* probability, bar graphs, line graphs, histograms, and the mean as a measure of central tendency.

The Science Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Science Through Eighth Grade

Science education[5] focuses on fostering students' logical thinking skills and preparing students for lifelong learning. The focus of the curriculum is on knowing basic science facts, observing and acquiring skills, and acquiring a positive attitude toward science. The suggested approach to teaching and learning is problem solving and the active participation of students in practical activities and conducting experiments.

Knowing basic science facts means that students should become familiar with the basic and necessary facts in the physical, life, health, and earth sciences and know about important applications of science in real life. In this way, they should know about basic concepts of science such as energy, living beings, the Earth, and natural phenomena.

Observing and acquiring skills refers to making observations, measurements, collecting data, analyzing results, making conjectures, communicating, predicting and using instruments, and planning and conducting an investigation.

Acquiring a positive attitude toward science focuses on helping students think about and search for the cause of phenomena and fostering a sense of curiosity to finding the causes of natural phenomena in the surrounding environment, encouraging them to use their skills to investigate the answers to their questions about science, fostering interest in saving energy and time, helping them observe personal and public hygiene, and interesting them in environmental issues.

By the end of **fourth grade** students have learned the following.

- *Life science, which includes learning about animals and plants*: (animals) diversity; habitats and the need for keeping the environment clean; types of food; types of locomotion; nesting and migration; comparing different animal covers and the advantage of different covers and animal needs; classifying vertebrates and invertebrates and learning about their habitats; types of parasites; and the body structure and characteristics of living beings; (plants) the main parts of plants and their structure and the function of roots, stems, leaves, flowers, and fruits; plants and clothing; the growth of plants and different factors affecting the growth of seeds; comparing monocotyledons and dicotyledons; classifying plants; the study of cones; the structure and function of cells; photosynthesis; and the role of vessels in plants and plant uses in nutrition, agriculture, pests, and pesticides.
- *Earth science*: locations, purification, and the proper uses of water; rocks, minerals, sand, and soil; the use and conservation of Earth's natural resources; the solar system; Earth's rotation on its axis and day and night and shadows; and air and its purification.
- *Health science*: senses and learning through the senses; protection of eyes and ears; staying healthy; growing and factors affecting growth; the digestive system and its function; bones and muscles; the respiratory system; and blood circulation.

- *Physical science, which includes learning about heat, motion, matter, force, energy, light and reflection, electricity, and magnets*: (heat) temperature changes in different places; the effect of color on absorbing sunlight; applications of heat; heating appliances; sources of heat; what materials to wear in cold and warm environments; changing states of materials and the effect of heat on states of materials; and how to put together and work with a thermometer; (motion) moving and stationary objects; wheels and their applications; the effect of surfaces on motion; and the effect of weight on motion; (matter) states of matter; volume, mass, and comparing the volume and mass of materials; the structure of matter; the types of mixtures and comparing mixtures; and solution and solvents: (force) the concept of force and the effect of force on the movement of materials; and the Earth's gravity and comparing the Earth's gravity on different objects; (energy) types, proper use, and conversion of energy and the different sources of energy applications; (light and reflection) the role of light in seeing objects; sources and applications of lights; light refraction; shadows; types of mirrors; the image of objects in different types of mirrors; and mirror applications; (electricity) electric currents; electrical circuits; insulators and conductors; and parallel and series circuits; (magnets) different shapes of magnets; magnets and different objects; magnet applications; comparing magnets; electric magnets; magnet poles; and finding locations with a magnet.

By the end of **eighth grade**, students have learned the following.

- *Life science*: classification of living beings; organ systems in humans and how they function; cell structure and function; photosynthesis and respiration; life cycles of organisms; interaction of living organisms in an ecosystem; the cycle of materials in nature; trends in the human population and its effects on the environment; the impact of natural hazards on humans, wildlife, and the environment; microorganisms and infectious diseases; ways of transmission and prevention; and preventive medicine methods.
- *Earth science*: the atmosphere and its components, the water cycle including steps in the cycle, the role of the sun's energy, and circulation or renewal of fresh water; processes in the rock cycle and the formation of igneous, metamorphic, and sedimentary rocks; the Earth's resources including renewable or nonrenewable sources, conservation, and waste management; and the supply and demand of fresh water resources.
- *Physical science, which includes physics and chemistry*: (physics) the effect of heat on the processes of melting, freezing, evaporation, and condensation including phase change, melting or boiling points, and volume; measurement of heat and its units; temperature; heating; pressure; energy forms; basic properties or behavior of light including reflection, refraction, light and color, image formation in mirrors, and lenses; wave and energy and the properties of a wave; conservation and transformation of energy; simple machines; power; work and calculating work; sound wave and sources of sound; electric circuits including the flow of currents and types of circuits; conductors and insulators; resistance; properties

of permanent magnets and electromagnets; forces and motion including types of forces, measuring force, mass, weight, and a basic description of motion; distance and displacement; velocity; and acceleration; (chemistry) the classification and composition of matter including physical and chemical properties, pure substances and mixtures, and separation techniques; the particulate structure of matter including molecules, atoms, protons, neutrons, movement of particles, electrons, the atomic model, symbols and notations, atomic bonds, molecular bonds, and ions; solutions including solvents, solutes, and the effect of temperature on solubility; acids and bases; chemical change and reactions; mass and chemical change; physical change; energy and physical or chemical changes; and the classification of familiar chemical transformations such as releasing or absorbing heat or energy.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Time

For all grade levels, the school year is generally 9 months long and begins on September 21 of each year and ends on June 21 of the subsequent year. Schools operate Saturday through Thursday. The instructional time for fourth grade mathematics is 3 hours and 20 minutes, which is 16 percent of total instructional time. Total instructional time for fourth grade science is 2 hours and 15 minutes (three periods of 45 minutes each), which is 13 percent of the total instructional time per week. Total instructional time for eighth grade mathematics and science is 3 hours and 20 minutes each (4 periods, each 50 minutes), which is 11 percent of total instructional time.

Instructional Materials, Equipment, and Laboratories

In primary schools, the use of measuring tools is suggested. Almost all teachers use workbooks of their own choice. All of the curriculum and textbooks are prepared by the Organization for Educational Research and Planning. All mathematics textbooks, up to eighth grade, are accompanied by a teacher's edition and a teacher's guide, within which recommendations for teaching and suggested teaching-learning and assessment methods and activities are provided.

In science, the use of laboratories is part of the program of study. Laboratories are equipped by both the Ministry of Education and schools, which also use these laboratories for extracurricular activities.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

In almost all middle schools and, recently, in a lot of primary schools, teaching of mathematics and science is being done by specialist mathematics and science teachers.

Use of Technology

Use of video tapes, overhead projectors, calculators, and computers in all areas and all levels is recommended but not mandated. The decision on their use is made by the school and the teacher. Currently, there are several schools in large cities that are using educational software or integrating the Internet into their process of teaching-learning. Some tapes and CDs are prepared by the Ministry of Education.

Teachers and Teacher Education

Education and Training for Fourth and Eighth Grade Mathematics and Science Teachers

Mathematics and science is taught by teachers who hold mathematics and science degrees and go through one of the following programs.

Teacher training centers affiliated with the Ministry of Education are postsecondary institutes. Those high school graduates who wish to continue their studies in these centers take part in a nationwide entrance examination. Students at these centers are boarded there during their 2-year studies. After completing the courses, students are awarded an associate's degree and teach in primary or lower secondary schools. The programs offered at these centers include mathematics, experimental science, physical education, social studies, primary education, the Persian language and its literature, fostering affairs (graduates of this program provide pedagogic advice, plan for leisure time and school activities, and work in student affairs), the Islamic and Arabic languages, art and exceptional education (for learning how to teach students who have intellectual disabilities and visual and hearing impairments).

Teacher training programs at universities and higher education institutes train teachers for secondary education. Students who study in these programs have to take national higher education entrance examinations, and pedagogy and educational psychology courses, along with specialized courses.

Teacher Professional Development in Mathematics, Science, and Technology

In order to update teachers' knowledge and skills, the Bureau for the Scientific Promotion of Human Resources develops short- and long-term courses and workshops with both general and specific education content.[6] These are provided in different institutes for ministry staff, including teachers. Long-term courses lead to either an associate's, bachelor's, or master's degree. The goal of short-term training courses is to improve the specific competency of teachers and educational staff. Participating in courses such as pre-employment training, training for promotion, and teacher training is compulsory. The approach to planning for and implementation of these courses is both centralized and decentralized. Also, to advance proficiency and the skills of teachers in using technology, teachers are required to take computer literacy courses.

Expert teachers, responsible for monitoring and helping teachers in different subjects and answering their questions, are available in all districts. There are professional, instructional, or educational associations in the head offices of the Ministry of Education in each province where teachers may address their problems and seek help. The Curriculum Development Center and other sites also provide help or instruction to mathematics and science departments and teachers.

Examinations and Assessments

At the primary level, students are assessed internally with two semi-annual examinations in each grade. At the end of 5th, 8th, and 11th grades, and the pre-university stage, a final assessment is developed by the provincial offices of Evaluation and Assessment in the Ministry of Education. Those who pass the fifth grade examination are issued an elementary school-leaving certificate, and those who fail are given the opportunity to retake the examination in September. Students who fail a second time are giving the opportunity to retake the examination the following year. Those who pass the eighth grade regional provincial examinations are awarded a Certificate of General Education. Those who pass the 11th grade nationwide final examination are awarded a high school diploma. Students who pass the pre-university stage examination are eligible to take part in national entrance tests for entering into a university program.

The grading system at the primary level uses points that are earned through continuous assessment and criteria-based written and oral examinations. Ten (out of 20) points are required for promotion. The system for lower secondary school is similar to that used in the primary stage.

Monitoring Individual Student Progress

Educational evaluation of students, conducted by individual teachers, includes school-based formative and summative assessments. Formative assessment is done through continuous assessment of students' in-class activities and several in-class oral or written tests, as well as feedback on homework. Reports of students' progress are sent to their parents.

Grade Promotion and Retention Policies

Children in the preprimary stage are promoted automatically to the next stage. As mentioned earlier, students at the other levels must pass an examination in order to be promoted.

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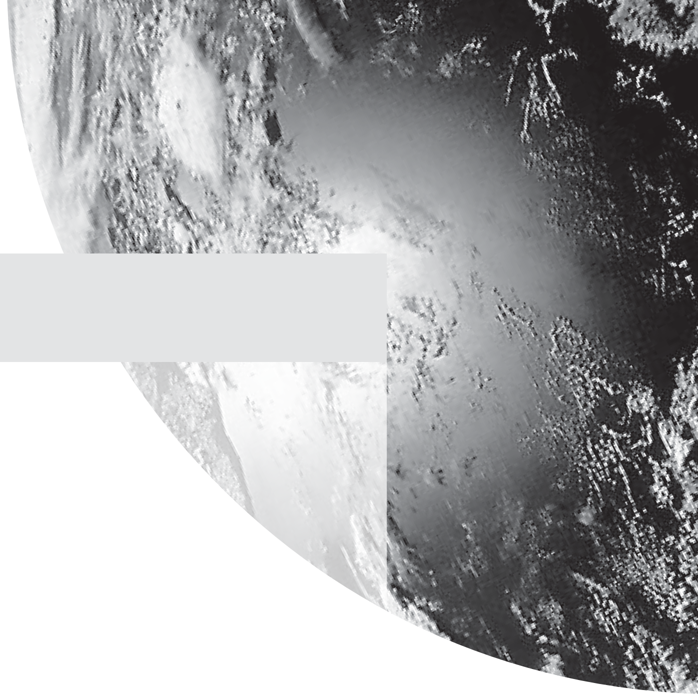

Israel

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Introduction

Overview of Education System

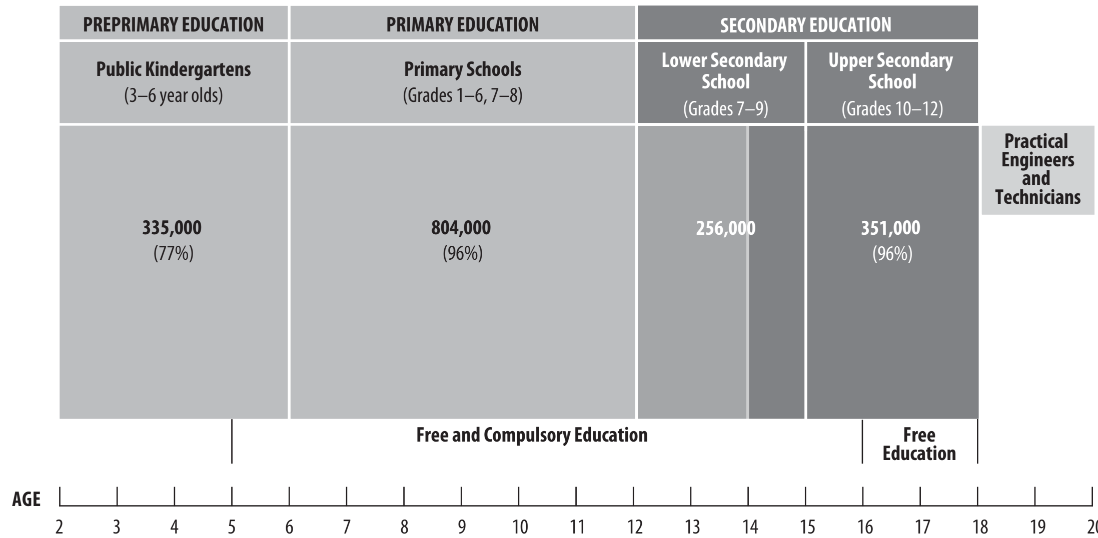
The education system in Israel moves cyclically between a centralized and a decentralized model of policy-making. The present education system in Israel, with its network of regional administrations and a body of inspectors, is very centralized. The Ministry of Education is very influential in dictating curricular and pedagogical actions, making decisions concerning budget and budgetary criteria, and also is involved in an ongoing process of bringing educational standards in-line with modern pedagogic practices.

The formal education system, shown in Exhibit 1, consists of the following levels: preprimary education (ages 2–6); primary education (ages 6–12); and secondary education, which includes lower secondary education (ages 12–15) and upper secondary education (ages 15–18). Free and compulsory education extends over 11 years, from kindergarten to grade 10. The last 2 years in secondary education, grades 11–12, are free but not compulsory.

The numbers in Exhibit 1 refer to students under the supervision of the Ministry of Education, including the percentage of students in that age group enrolled in each level of the education system (shown in parentheses). The percentage given for those attending secondary schools also includes students attending institutions supervised by the Ministry of Labor or the Ministry of Religious Affairs.

Although most primary schools educate students for 6 years, about 25 percent of schools at this level are 8 years. At the secondary level, there also are some 6-year comprehensive high schools. Secondary schools are further divided into two main types: general and technological-vocational. One-track secondary schools provide either one of these types of education, while multitrack schools offer both tracks.

Exhibit 1 Structure of the Education System in Israel, 2005–2006



SOURCE: Segev, Y., Bar, E., & Mazloum, D. (2007). *Facts and Figures* (p. A9), (in Hebrew). Jerusalem: Ministry of Education, Economic, and Budgeting Administration

The initiation of a new curriculum is the responsibility of the head of the pedagogical secretariat, who appoints a committee of subject area experts, including the chief inspector of that field. This committee sets guidelines for the new curriculum. Another committee is appointed by the ministry's Division of Curriculum Planning and Development to develop a syllabus that has to be confirmed by the head of the subject area committee. These rules apply to the curriculum in mathematics and to the curriculum in science and technology.

Most schools in the education system are public schools, with the government contributing more than half their budget either directly or indirectly via local authorities and nonprofit educational institutes. Schools are divided by their language of instruction: Hebrew or Arabic. There are a very small number of private schools. A small percentage of the schools, mostly at the primary level, are special education schools. In the 2005–2006 school year, 1,745,000 students were enrolled in the formal education system from the preprimary level to the end of the secondary school (1,306,000 in Hebrew-speaking schools and 439,000 in Arabic-speaking schools).

Special funding for mathematics and science occurs in waves, when the Ministry of Education decides to give these areas of study a priority. Such priority was given to mathematics and science and technology in the late 1990s. The annual budget of the science and technology administration is currently about NIS 60 million (NIS is the currency of Israel),[1] but this budget does not include additional funding that is allocated via other administrations or branches of the Israeli Science and Technology Center. The latter are located in some universities and support the development of learning materials and professional development courses for leading teachers.

Mathematics is one of the school subjects that requires matriculation examinations. Science is not. The curriculum for mathematics and for science and technology in both primary and lower secondary levels serves all students with no special tracks. Upper secondary schools have different tracks based on the breadth of study (basic three study units versus four or five study units for advanced tracks).[2]

Language and Population

At the end of 2006, Israel's population of approximately 7.1 million citizens was 75.8 percent Jewish, 19.9 percent Arab (83% Moslem, 8% Druze, and 9% Christian), and 4.4 percent non-Jewish immigrants.[3,4] Israel has been a land of Jewish immigration. In 2003–2004, there were about 150,000 immigrant students, 63 percent from the former Union of Soviet Socialist Republics, 10 percent from Ethiopia, 10 percent from the United States, and the rest from other countries.[5] As a result, a great variety of languages are spoken. However the two official languages in Israel are Hebrew and Arabic. English is the major foreign language used for wider communication.

Schools are split according to their language of instruction into Hebrew-speaking schools and Arabic-speaking schools. Mathematics and science are thus taught in Hebrew in Hebrew-speaking schools and in Arabic in Arabic-speaking schools.

Second-language Instruction

In Hebrew-speaking schools, English is the second language studied and in Arabic-speaking schools, Hebrew is the second language, usually studied beginning in the third grade.

Emphasis on Mathematics and Science

There were two, large education reforms in Israel regarding mathematics and science and technology. The first education reform[6] was in the early 1990s and focused specifically on mathematics and science and technology. In mathematics, the plan recommended mathematics be taught by expert teachers in primary schools and suggested establishing intensive teacher professional development programs to be implemented through regional teacher centers. At the lower secondary level, the plan recommended a pedagogical shift toward the development and consolidation of quantitative thinking and graphical interpretation skills. For the upper secondary schools, the plan recommended special, attractive programs to encourage students to pursue advanced mathematics tracks.

For science and technology in lower secondary schools, the main recommendation was to develop an integrated science and technology curriculum with relevance to societal issues (a similar program was already running in primary schools) and to promote scientific and technological literacy—the type of knowledge needed for adult life. At the upper secondary level, advanced disciplinary courses in science and technology were advocated for those who wished to pursue careers in these fields. Intensive preservice programs for prospective teachers and teacher professional development programs in regional teacher centers and in teacher education institutions were recommended for those who would teach the new, unified subject.

The second reform, at the beginning of 2000, in line with an already growing tendency toward outcome-oriented policy-making, focused on accountability mechanisms and monitoring activities and the establishment of a new, national authority for assessment.

As a result, the focus has been on developing achievement and performance standards in mathematics and science and technology. These standards and benchmarks are meant to guide instruction in these fields.

Regular programs for fostering mathematics and science and technology are carried out in schools. These programs target two populations—very talented students and students who have difficulties or who are not achieving though they express interest in these subjects. The ministry also runs a special program, with the goal of encouraging girls to take advanced studies in mathematics and science and technology. There also are international and national Olympic competitions in the fields of mathematics, biology, chemistry, physics, computer science, and robotics.[7,8]

Overarching Policies Related to Education and the Curriculum for Mathematics and Science

IEA studies, among them TIMSS, consider the curriculum to be a major determinant of student achievement. As a result of Israel's participation in TIMSS study cycles (in 1995, at all grade levels and in 1999, 2003, and 2007, only in eighth grade), Israel increased the amount of mathematics and science topics that appeared in the international framework in the Israeli official mathematics and science curriculum from 41 percent in 1999 to 69 percent in 2003 in mathematics and from 57 percent in 1999 to 77 percent in 2003 in science.[9]

Another major impact of the IEA studies is related to the empirical way of defining achievement levels in the different subjects tested in these studies. The description of these benchmarks was used in Israel and elsewhere in national-scale attempts to define standards in mathematics and science.

Finally, the IEA studies pointed to the need for changes in Israel's assessment methodologies at the national level. Innovative psychometric techniques were adopted and the released TIMSS items were used as exemplary assessment tasks for test item writers, as well as for pedagogical purposes by teachers.

The Mathematics Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Mathematics Through Eighth Grade

Both the primary and lower secondary mathematics curriculum in Israel went through intensive revision partly due to Israel's participation in TIMSS. In 2002, a committee[10] was appointed to examine and recommend improvements in mathematics teaching at all grade levels. The committee identified deficiencies in solving verbal problems and geometry, a tendency of narrowing the curriculum to the topics that appear only in the matriculation examinations, and ethnic as well as socioeconomic achievement gaps between subpopulations in Israel. At approximately the same time, other committees[11,12] concluded that the common instructional approach emphasized computational skills and not mathematical reasoning, the primary and secondary curriculum were not connected, conditions for teaching mathematics were poor, there were crowded and heterogeneous classrooms, teachers had insufficient disciplinary knowledge, and there were not enough supervisors in the field.

One intervention, the Quantitative Reasoning Program, began in 2003 in more than half of junior high schools in Israel. This intervention emphasized the study of six topics related to quantitative thinking, establishing a link between what was learned in primary and lower secondary school, and improving students' ability to cope with mathematical problems that require the integration of skills learned in other school subjects. After a period of revision, a new curriculum for primary and lower secondary schools was introduced in 2006, which is described below.

The goal of the new curriculum for **primary grades** is to attain basic concepts and structures in arithmetic and geometry, as well as develop mathematics skills and abilities, such as learning number sense and geometric insight, learning computational skills, using mathematical tools to solve verbal problems mathematically, and having conceptual understanding and knowledge of mathematical language.[13] Attaining mathematical concepts is considered a cumulative process dependent on students' ability to grasp these concepts and linked to other school subjects and the real world. The primary mathematics school curriculum, up to fourth grade, includes the following topics.

- *Numbers and operation* and *data investigation*: natural numbers, the four arithmetic operations, simple arithmetic operations (subtraction and addition) with fractions, fractions (common and decimals) with all operations, transferring from one form to another, percentages, and proportion.
- *Geometry and measurement*: geometric shapes (polygons, triangles, squares, rectangles, and three-dimensional shapes such as rectangular prisms); measurement of length, area, volume, angles, etc.; transformation and symmetry; quadrilateral properties; circles; classification of three-dimensional shapes; and computation of volume.

The curriculum for **lower secondary schools** mainly covers four domains: numbers, algebra, data and chance, and geometry. In the new mathematics curriculum for both seventh and eighth grade, 25 percent of the curriculum is focused on geometry. Algebra remains the main topic in ninth grade. Data and chance have a minor emphasis and appear only in seventh and eighth grades.

The distribution of the main topics over the three grade levels of lower secondary school is as follows.[14]

- **Grade 7**. *Numbers* topics include negative numbers, fractions and decimals, percentage, and the Cartesian plan. *Algebra* topics include patterns, algebraic expressions, and equations. *Data and chance* topics are data organization and representation and interpretation. *Geometry* topics are formulas for perimeter and the area of rectangles, triangles, and the volume and surface area of boxes.
- **Grade 8**. *Numeric* topics are related to ratio and proportion and real numbers. *Algebra* topics include linear equations and algebraic expressions. In *data and chance*, the topic is chance. In *geometry*, the topics are geometric shapes and Euclidean geometry, including axioms, theorems, and proofs.

- **Grade 9**. *Algebraic* topics include fractions in algebraic expressions, linear and quadratic functions, and quadratic equations. In *geometry*, the topic is Euclidean geometry, including triangles (isosceles, equilateral, and right triangles) and quadrilateral shapes.

The Science Curriculum in Primary and Lower Secondary Grades

Since the 1980s, the science curriculum in Israel at both the primary and lower secondary levels has centered on scientific and technological literacy and has included the mastery of significant facts, concepts, principles, and theories of each scientific discipline; a grasp of science and technology processes and their impact on society; and, above all, the ability to use this knowledge for personal and societal needs. Beyond providing key concepts and ideas in science and technology, the general objectives of this curriculum are to highlight the similarities and differences between the two disciplines; indicate their contributions and limitations; and develop intellectual competencies such as inquiry skills and decision-making skills, as well as performance skills for design and practical problem solving.

In general, the science curriculum is not mandatory beyond the lower secondary level. Students are not required to study toward a matriculation certificate in science and technology, and thus, many end their studies in the ninth grade. Currently, some attempts are being made to ensure that every youngster will study three learning units in science and technology toward matriculation examinations.

The science and technology curriculum for **primary schools** includes seven content domains and a set of cognitive and practical skills to be attained: matter and energy; the man-made world; man, health, and the quality of life; the world of living organisms; ecosystems and the environment; the Earth and the universe; and information and communication. Each domain is divided into subdomains that contain a specified and detailed list of topics. These topics are further elaborated into a scheme of standards for each grade level. Each standard describes the scientific, technological, and societal aspects of every topic.

The topics are designated into three levels (grades 1–2, grades 3–4, and grades 5–6), and students progress in a spiral way from one level to the other depending on their developmental cognitive stages. The syllabus does not define the sequencing of the topics, and teachers are encouraged to decide on suitable sequencing and meaningfully connecting topics.

In addition to the content domain, the goal of the curriculum also is to attain cognitive and performance skills. This component is woven into the learning of content. Four, nonmutually exclusive groups of skills are defined as follows: processing information and information handling skills; investigation discovery and problem-solving skills; performance skills; and learning and communication skills.

Building on the elementary syllabus, the curriculum for science and technology in **junior high school** imparts basic concepts, modes of thought, and problem-solving strategies in science and technology aimed at the entire population. The curriculum is meant to build a foundation for students who will specialize in other fields, as well as a basis for advanced studies for those who will choose to specialize in science and technology disciplines in upper elementary grades. The list of topics contains the following: materials including structure, properties, and processes; energy and interaction; technological systems and products; information and communication; the Earth and the universe; organisms including phenomena, structures, and processes; ecosystems; and elective studies such as systems in science and technology. An effort is made to represent or delineate, in each topic, the scientific aspect, the technological aspect, and the societal aspect.

Skills and cognitive processes are divided into two main categories: cognitive and learning skills. Cognitive skills include strategic skills, logical and critical thinking, reflective thinking, probability thinking, and creative thinking. These are subdivided into locating, collecting, and transferring data; processing and representing data; and written and oral presentation of knowledge. The second category, investigative and problem-solving skills, incorporates processes characterizing scientific-technological endeavors, such as planning an investigation, conducting data analysis, and drawing conclusions.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Time

Decisions regarding instructional time are not always an outcome of pedagogical considerations. In many cases, they reflect budgetary constraints. In mathematics, the intended and actual allocation of study hours are the same. Mathematics is taught in primary grades 1–6 for 5 hours weekly and in the lower secondary schools for 4 hours weekly. The intended hours science and technology should be taught weekly in each grade are: 1 to 2 hours in grades 1 and 2, 3 to 4 hours in grades 3 and 4, 5 to 6 hours in grades 5 and 6, and 6 hours in grades 7, 8, and 9. Science is actually taught weekly at the primary level for 2 to 3 hours and in seventh grade for 3 hours.

Instructional Materials, Equipment, and Laboratories

In mathematics and science and technology, a list of specifications for materials and equipment is published every year. Textbooks or other learning materials are developed either by governmental bodies (such as the Center for Curriculum Planning and Development or branches of the Israeli Center for Mathematics and Science Education) or by private publishers. In mathematics, the bulk of learning materials is produced by private publishers. All learning materials have to be approved by two evaluators from a special unit of the ministry (a subject matter specialist and a pedagogical expert). Beginning in third grade, it is recommended that science and technology studies be conducted in the school's science and technology room (laboratory), a multipurpose room suitable for both scientific and technological investigation.

Grade at Which Specialist Teachers for Mathematics and Science Are Introduced

Beginning in grade 3 in science, it is recommended that science and technology be taught by a specialized teacher. It is recommended that mathematics be taught by a specialized teacher beginning in grade 1. In spite of the recommendation and action taken to professionalize teachers, this is not always the case since there is a shortage of suitable candidates or available positions in schools.

Specialist teachers can serve as subject coordinators in their schools. Beyond their initial training, they participate in additional courses aimed at updating them in new curricular materials and subject matter advancement.

Use of Technology

As a result of reform in instruction in the areas of mathematics and science and technology, one priority was establishing a suitable infrastructure (i.e., computers, laboratories, and a shift toward using them as part of routine instruction). In mathematics, the use of computers is limited due to lack of hardware and low motivation of teachers. The popular tool used is a calculator, but only beginning in the lower secondary grades. Graphic calculators are not available. In science, the use of computers is part of teaching, especially when it makes a special contribution, such as enabling literature search, data processing, and simulations.

Homework Policies

There is no official policy concerning homework, although it is assigned on a regular basis in mathematics. Homework in science focuses more on projects.

Teachers and Teacher Education

Education and Training for Fourth and Eighth Grade Mathematics and Science Teachers

Initial teacher education takes place in colleges of education and teacher education departments in schools of education at the universities. A teaching certificate can be obtained through a graduate program offered in six universities. Typically, these programs extend over 1 or 2 years, 28–32 hours per week, excluding prerequisite courses and practicum. Since 2003, an induction year has been added as a new requirement for obtaining a teaching license. An induction year is defined as the first year of a teacher's work in the profession.

Teacher education at colleges of education takes place at more than 50 institutions, both secular and religious, of which only 27 are academic colleges. Teacher education in colleges combines disciplinary and pedagogical content. Typically, regular academic studies in colleges of education extend over a 4-year program (110–115 hours annually, including a 1-year induction program) and grant a bachelor's degree in education.

Since 2000, a new license for all levels of education has been required both from university graduates and teacher college graduates. The prerequisite for obtaining this license is having a teaching certificate, an academic degree, and the successful completion of the induction year.

In 2006, a new outline for teacher education programs was proposed for universities and colleges of education[15] stating that the basic pedagogical component in the program extend over 24–30 hours annually and contain education studies, research methodology, and pedagogical studies, including a supervised practicum. This component complements 60 hours per year of disciplinary studies, taught either as part of university undergraduate studies or in a concurrent model at the colleges of education.

In 2005–2006, approximately 60,000 teachers were teaching in primary schools and 23,000 in lower secondary schools.[16] Of the primary level teachers, 3,500 are teaching science and technology. Most have graduated as general primary school teachers and also completed the 720 hours required for teaching the new curriculum. In lower secondary schools, 4,500 teachers are teaching science and technology. These teachers either completed their Bachelor of Education studies in teacher colleges in science and mathematics tracks for lower secondary schools or obtained their degrees in science or mathematics and teaching certificates at the universities. Some teachers who teach in the lower secondary grades also teach in the upper secondary grades.

At the primary level, 9,403 teachers teach mathematics. Only 18.3 percent of them have majored in mathematics, and about half of them completed special professional development courses aimed at professionalizing them as mathematics teachers. At the lower secondary level, 2,918 are mathematics teachers, of which about 41.7 percent of them have specialized in mathematics as their main area of study.[17, 18]

According to the Ministry of Education, there is no evidence of shortage in science and technology teachers either at the primary or lower secondary levels.[19] This is not the case in mathematics where the demand for teachers at all levels exceeds the supply.[20]

Teacher Professional Development in Mathematics, Science, and Technology

Teacher professional development is offered primarily by institutions of higher education, universities, and teachers' colleges, but some are located in special professional development teacher centers. Since 2002, there has been an attempt to merge all teacher centers under one organizational umbrella called Centers for Professional Development of Educational Teams. Among the activities aimed directly at mathematics and science teachers are courses for specialized primary teachers promoting specialization in mathematics and science and technology training. All courses currently offer teacher credits that translate into pay rises. One credit unit equals about 112 hours of study, and the maximum amount of credits a teacher can gain is 24.75.

There are four types of teacher professional development frameworks: group training intended to facilitate policy implementation, which are planned and organized by the Ministry of Education; task-oriented, professional development training, also initiated by the ministry that prepares staff for certain functions (e.g., principals, coordinators, and leaders); school-based training, aimed at responding to school needs and organized by the schools themselves; and personal training, chosen by the individual participant, that provides professional enrichment and furthers education.

In order to prepare teachers to teach the unified subject of science and technology at primary and lower secondary school, they were required to participate in an extensive professional development program of 720 hours (lasting 3 years). In mathematics, a similar 3 year program (120 hours per year) for professionalizing primary teachers was introduced in 2002 in several teachers' colleges. This program is offered to teams of teachers from schools and is followed by evaluation processes in these schools.

Examinations and Assessments

National or Regional Examinations

In 2005, a new National Authority for Measurement and Evaluation in Education replaced an internal body in the ministry and was granted an independent status, directly accountable to the Minister of Education. As a result, many changes occurred in the examination and evaluation systems in Israel. The main shift was from measurement for accountability purposes toward measurement and evaluation in the service of learning and policy-making.

Different assessment activities that flourished in the past are being replaced by a coordinated system of assessment activities that are standards based. These activities, aimed at a wider student population, are cyclical, and linked over years. They are created by external as well as school-level experts and are summative as well as formative in nature. Currently, these are being carried out mostly on samples of schools.

Among the national assessment activities is a national feedback monitoring mechanism that conducts regular external examinations on national samples testing different subject areas of the curriculum in depth. This is mainly aimed at policy-making. There also is a school feedback mechanism that focuses on growth and effectiveness measures for schools called GEMS (*Meytzav*). Rotational testing is conducted in four subjects: the mother tongue (i.e., either Hebrew or Arabic), mathematics, science and technology, and English. These tests are administered at grades 2, 4, 6, and 8 in clusters of Hebrew-speaking schools, along with questionnaires concerning the school climate and the teaching environment. This includes a school-based external examination each year in two of the four subject areas, as well as an internal examination in those subjects not covered by the external exams. Schools do not report on the results of the internal testing. Support is given to schools to use the information gathered for the purpose of student evaluation and monitoring progress at the school level.[21]

Choosing a career in mathematics and science and technology is dependent on having completed advanced studies in these fields (determined by the number of study units the student is exposed to) and on obtaining an enhanced matriculation certification. Thus, continuous effort is made to increase the percentage of students entitled to receive an enhanced matriculation certification in mathematics and science. One way to achieve this is by allowing a cumulative examination system that enables students to gradually master study units and be examined on them.[22]

The matriculation examinations are regarded as the official test to measure the results of the 12 years of compulsory schooling in Israel. They are high-stakes examinations, often used to determine access to higher education and covering all subject areas taught in secondary school. The depth of studies, represented as learning units, as well as the hours invested in learning, dictates the difficulty of the tests. Learning units range from one to five, each representing 90 hours of study. Most of those students who took enhanced examinations were entitled to a matriculation certificate.[23] Of the students who took the mathematics examinations in the 2005–2006 school year, 87 percent took the enhanced (advanced) matriculation examination; 73 percent enhanced took the advanced examination in physics, and 74 percent took it in chemistry.

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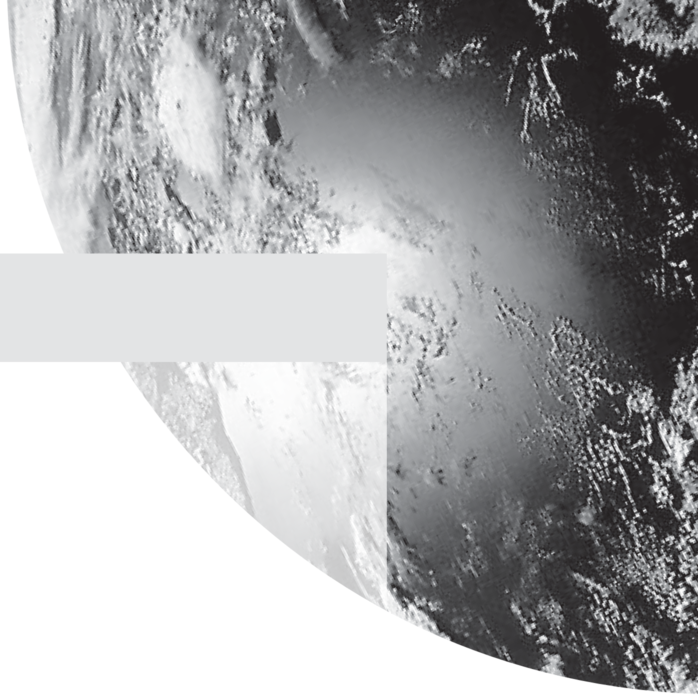

Italy

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Introduction

Overview of Education System

The Constitution of the Italian Republic not only promotes the development of culture,[2] but it recognizes and guarantees to all its citizens the right to an education.[3] The Republic establishes the general norms for education and is responsible for state schools of all levels and types.[4] The institutions of high culture, universities, and academies have the right to establish their own regulations within the limits of the laws of the state.[5]

The Ministry of Education is the institution that manages knowledge. Its tasks are to organize school education, levels, curriculum, and the legal status of personnel; recognize qualifications and certifications at a European and international level and implement common European Union education policies; and establish educational objectives, standards, and processes for education and training. All Italian schools depend on the Ministry of Education to do the following.

- At a central level, the ministry establishes the general norms and advice that is applied, at a peripheral level, by the regional school offices.
- At a peripheral level, the regional school offices of the ministry constitute autonomous centers of administrative responsibility. They implement the decisions of the departments and play a direct support and advisory role for individual schools through specific offices set up throughout the country. In cooperation with the Department for Education, these offices plan activities to support the autonomous schools, develop relationships with the regional government and local boards to construct an integrated educational offering, coordinate the distribution of financial and human resources at a regional level, and coordinate the monitoring and evaluation of resources.

Education is compulsory from ages 6–16 or until a professional qualification is obtained by this age.[6] The education system in Italy is divided into preprimary, primary, secondary (lower and upper), and higher education.

Preprimary school, which is 3 years for ages 3–5, is not compulsory. Its goal is to contribute to the children's affective, cognitive, and psychomotor development and encourage their creativity, autonomy, and relationship skills. It guarantees equal educational opportunities and contributes to the children's overall education.

Primary school is 5 years for ages 6–11. It consists of a first year followed by two 2-year periods. Children learn their first approach to the world of culture and how to build concepts, connections, and meanings by interconnecting data from experience. Primary school has the function of neutralizing obstacles of a personal, environmental, and social nature that can hinder development. It gives children the opportunity to practice civil cohabitation and continues the process, started in the family and in infant school, of building and strengthening the child's personal identity. Children study the English language and basic computer science. A skill profile is developed, including a personal evaluation and orientation sheet, along with a mark for conduct that accompanies the child throughout the education system beginning at age 3.

Secondary school consists of lower secondary (first cycle) and upper secondary (second cycle). Lower secondary is 3 years, for ages 11–14, and includes a final 1-year orientation that offers students support in their academic or professional choices. The features of this cycle include learning a second European Union language besides English, more in-depth study of information and communication technology, and guidance in choosing one's further studies. This cycle ends with a state examination. Upon completion of this examination, students enter the second cycle and may choose between continuing their studies in upper secondary schools in a selected study (students can move freely from one study path to another) or entering the vocational training system (6–8% of the student population chose this path). If students go on to upper secondary schools, they can choose between the following.

- *Liceo classico*: the study of Latin and ancient Greek
- *Liceo scientifico*: the study of the sciences, mathematics, and physics
- *Liceo artistico and istituto d'arte*: the study of the visual and architectural arts
- *Istituto tecnico*: the study of industries such as tourism and handicrafts.

Higher or university education consists of an initial 3-year period, leading to a first degree, and then a final 2-year period, leading to a specialist degree.

In 2003, the education system, in general, was reformed in Italy.[7,8] The preprimary education system was completely reformed in 2004 in accordance with reforms of the whole education and training system.[9] In 2007, lower secondary education was reformed and refocused on improving guidance and evaluation.[10]

Schools can be run directly by the state (state schools) or by private individuals and organizations (nonstate schools). Although state schools have been given autonomy in teaching, organizational matters, research, experimentation, and development, they do not have financial autonomy. A bare minimum financial coverage[11] is provided by the state for a school's teaching and administrative functions. This funding is specific to each school type and level. Funding for vocational training is handled by regional school offices, with branch offices in each regional capital city.

Nonstate schools include those run by religious or lay organizations (*Scuole paritarie*).[12] These schools are eligible for state funding, have equal status with state schools, and their students are guaranteed the same treatment as state school students. These are the only nonstate schools that can issue qualifications that have a legal value. There also are nonstate schools run by citizens (with at least a high school diploma) that are authorized, private schools. These types of schools do not receive state funding.

Each regional capital city handles the provision of services and assistance for students (school meals, transportation, primary school textbooks, subsidies for less privileged families, and health care and welfare). At a provincial and/or subprovincial level are the Administrative Service Centers. Provincial and municipal authorities can provide assistance and services through regional authorities and also are responsible for providing school services. There also may be contributions from other public and private organizations for implementing projects, promoted and financed with resources destined for specific purposes.

Language and Population

The official language is Italian, which is used in teaching all school subjects. In some areas of the country that have native speakers of other languages, the local language is used in school instruction. These regions include the following: Valle d'Aosta, where French also is taught as a native language in addition to Italian; Trentino Alto Adige, including the autonomous province of Trento, where Ladin also is taught with Italian instruction; the province of Bolzano, where some schools teach German, Italian, and Ladin; and Friuli Venezia Giulia, where Slovene is taught.[13] Laws have given the Slovenes, the German-speaking minorities, and the Friulano-speaking population a special status that safeguards their languages.[14]

Second-language Instruction

English language teaching begins in the first year of primary school. The program ranges from functions, such as recognizing commands, instructions, simple phrases and spoken messages, and understanding and reproducing songs (first year), to understanding and producing familiar everyday expressions, common set phrases, and connecting words and groups of words (second 2-year period).

Secondary school continues the study of the English language and also introduces a second European Union language. For English, the program ranges from understanding the main information contained in spoken messages and producing oral texts (2-year period) to completely understanding oral messages in more detail, as well as short, written texts and interacting in short conversations even on unfamiliar themes (third year).

Learning the second European Union language in lower secondary education includes the overall understanding of words, simple phrases and, with reference to Italian, the overall sense of a short text in the foreign language (2-year period) and to fully understand short spoken messages and participating in conversations on familiar themes (third year).

Overarching Policies Related to Education and the Curriculum for Mathematics and Science
The study programs for mathematics and science are established by national indicators.[15] In education, there are no specific funds allocated for mathematics and science.

The Mathematics Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Mathematics Through Eighth Grade
The following is the mathematics curriculum for the **fourth and fifth years of primary school**.

- *Numbers*: learning relations between natural numbers; consolidating the four arithmetical operations and their algorithms; learning (an introduction to) integers in concrete contexts; learning order of integers in the numerical sequence; learning (an introduction to) decimals; learning intuitive notions of fractions and their symbolic representations with reference to concrete contexts; learning different written forms of the same number (fractions and decimals); learning size and approximation; recognizing and building relations between natural numbers (multiples, divisors, prime numbers, etc.); reading and writing natural numbers and decimals; comparing and ordering decimals and working with them; representing numbers in numerical sequence; comparing and ordering simple fractions by suitably using the number line; performing the four arithmetical operations with decimals with the awareness of the concept and mastery of algorithms; beginning mental arithmetic procedures and strategies by using the properties of operations; making approximate calculations; making forecasts on the results of calculations performed with mini-calculators.
- *Geometry*: consolidating the concept of an angle; analyzing the significant elements (sides, angles, etc.) of the main geometric figures in a plane; learning the names of triangles and quadrilaterals and their symmetries, the length of the sides and the size of the angles; recognizing symmetries, rotations, and translations; using angles in concrete contexts; exploring models of geometric figures; building and drawing the main geometric figures; identifying symmetries in given objects or figures and highlighting their features; and recognizing rotated or translated figures by performing the necessary transformations.
- *Measurement*: identifying various and different measurable attributes of objects and associating measurement processes, system, and units of measurement to them; measuring length; determining, in simple contexts, perimeters, areas, and volumes of familiar geometric figures; understanding the convenience of using conventional units of measurement and becoming familiar with the metric-decimal system; performing simple conversions (equivalence) between one unit of measurement and another (between centimeters and meters, between grams and kilograms, etc.); understanding that measurement is approximate and grasping how the choice of a unit of measurement and the tool used affect

the precision of the measurement itself; and hypothesizing which unit of measurement is more suitable for measuring different attributes (e.g., the distance from Rome to New York, the circumference of a ring, and the surface area of a football field).

- *Introduction to mathematical thinking*: learning mathematical terminology and expressions concerning numbers, figures, data, relations, symbols, etc.; learning relations between objects (classifying objects, figures, and numbers according to one, two, or more given properties and vice versa, ordering elements according to a given characteristic, and recognizing the ordering assigned) and their representations; consciously using the mathematical terms introduced so far; verifying a formulated hypothesis through examples; classifying objects, figures, and numbers by making suitable representations; identifying, describing, and building significant relations in various contexts; learning similarities, differences, and regularities; analyzing the text of a problem and then identifying the information necessary to reach an objective, organizing a process for its solution, and applying it; and reflecting on the problem-solving procedure used and comparing it with other possible solutions.
- *Data and forecasting*: analyzing and comparing data gathered by means of statistics: the mode, median, mean, and standard deviation; searching for information contained in official statistics (through the National Statistics Institute and provincial and municipal authorities, etc.); identifying initial qualitative and quantitative characteristics of uncertain situations; consolidating data gathering skills and distinguishing a qualitative feature from a quantitative one; understanding how graphic representation and data processing depend on the nature of the data; understanding the need or usefulness of approximation of data gathered in order to decrease the number of modalities under observation; qualifying, with grounds, uncertain situations; and quantifying, in simple contexts, by means of information possessed, symmetry of outcomes and the frequency of similar situations.
- *Historical aspects linked to mathematics*: learning the origin of Indo-Arabic numerals, nonpositional writing systems and Roman numerals, and statistical issues of the past (e.g., the census and statistical tables regarding births, deaths, baptisms, and epidemics).

The following is the mathematics curriculum for the **third year of lower secondary** school.

- *Numbers*: learning number sets and the properties of operations; learning how to round decimals up and down with reoccurring and nonrecurring digits, and examples of irrational numbers; learning the magnitude, approximation, error, and the conscious use of calculating instruments; learning the formal writing of the properties of operations and the use of letters as generalizations of numbers in simple cases; learning the fundamental elements of algebraic calculations; learning simple first-degree equations; learning how to recognize various number sets with their formal properties and operating in them; performing simple sequences of approximate calculations; representing with letters the main properties of operations; exploring situations that can be modeled with simple equations; and solving equations in simple cases.

- *Relations*: learning significant relations (being equal to, a multiple of, greater than, parallel to, or perpendicular to, etc.); learning functions including tables and graphs; learning functions of the $y = ax$, $y = a/x$, and $y = ax^2$ type and their graphic representation; learning simple models of experimental facts and mathematical laws; identifying, describing, and building significant relations in various contexts and recognizing their similarities and differences; using letters to express properties and regularities in general simple forms (numerical, geometrical, physical, etc.); recognizing relations between magnitudes in facts and phenomena; and using Cartesian coordinates, diagrams, and tables to represent relations and functions.
- *Geometry*: learning circumference and the area of a circle; learning the meaning of π and some historical facts about it; learning further studies on solids, calculating volumes of the main solids and the areas of their surfaces (a cube, parallelogram, pyramid, cone, cylinder, and sphere); calculating the circumference and area of circles; visualizing three-dimensional objects starting from a two-dimensional representation and vice versa, and representing a solid figure on a plane; solving problems by using geometric properties of figures, by means of material models, simple deductions, and suitable representation tools (ruler, square, compass, and possibly geometry software); and calculating the volumes and areas of surfaces of the main solid figures.
- *Data and forecasting*: gathering data on continuous variables and constructing intervals of the same or different size; learning about frequency histograms; learning about relative frequency, percentages, and cumulative data; learning about the official sources of data and their use; understanding the classical, frequency-based, and subjective concepts of probability: constructing histograms and interpreting them; recognizing errors in graphs and correcting them; gleaning information from data and graphs of various sources; and using information and communication technology tools to organize and represent data.
- *Introduction to mathematical thinking*: grasping the basics of set theory and performing elementary operations using sets; learning, from natural language to formal language, propositions and the introduction of the logical connectors (not, or, etc.); calculating relative frequencies, percentages, and cumulative sums and giving them meaning; using relative frequencies, percentages, and cumulative sums to make comparisons between gathered data; understanding when and how to use different measures of probability (classical, frequency-based, and subjective); using different logical procedures including induction and generalization, deduction, function of examples, and counterexamples; justifying

statements and distinguishing between intuitive, hypothesized, reasoned, demonstrated, or observation-induced statements; documenting the problem-solving procedures chosen and applied; and critically evaluating the different problem-solving strategies.

The Science Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Science Through Eighth Grade

Students learn the following science curriculum for the **fourth and fifth years of primary school.**

- Horizontal and vertical direction; volume or capacity of solids and fluids; heat and temperature including fusion and solidification, evaporation and condensation, and boiling point; the water cycle, drinking water, and its responsible use; thermal and electric energy in everyday life; light, including its sources, shade, diffusion, transparency, and reflection; sound, including examples of sound production and propagation, intensity, tone, and pitch; and vision and hearing, the means for sensitive distance recognition.
- Organisms of higher order animals, with particular reference to man; changes in organisms: the life cycle of a plant and animal; conditions for the health of the human body, including hygiene and health.
- Using a spirit level and plumb line; measuring length, weight, and volume of material objects and correlating different magnitudes; determining the volume of water connected to various domestic uses; illustrating the difference between temperature and heat with reference to ordinary experiences; performing experiments on phenomena linked to temperature changes (evaporation, fusion, etc.); and characterizing the sound and light of a given environment.
- Observing and describing the human ear and eye; indicating examples of relationships of living things with their environment; recognizing the fundamental structures of animals and particularly of man; describing the life cycle of a plant, an animal, or man; personal hygiene, stating what it consists of and why it is important; indicating measures of prevention and what actions should be taken for dangers regarding heat and electricity sources; and introduction to the principles of mechanics with simple illustrative experiments.

Students learn the following science curriculum for the **third year of lower secondary school.**

- The flow of liquids, including the velocity of water and the flow rate of a channel or pipe; differences between temperature and heat and the thermometer; electricity, including concepts of electrical charge and current; magnetism, including magnets, the Earth's magnetic poles, and the compass; electromagnetic waves and radio signal transmission.
- The sun and solar system, from observations of the ancients to the hypotheses of contemporary science; the main movements of the Earth—rotation, revolution,

day and night, and the seasons; the globe, including its dimensions and structure; describing the main movements of the Earth and their consequences; showing how the sun's apparent movement allows identifying the seasons, latitudes, the time of day, and the meridian; naming the various kinds of rocks on the basis of their features and origins (igneous, sedimentary, and metamorphic), and analyzing their macroscopic features.

- Nutrition including foods and their components, food control, and harmful substances; the human nervous system and the effects of psychotherapeutic drugs, narcotics, or stimulatory drugs; general notions on the reproduction of living things and on genetics; sexually transmitted diseases; and reproduction in man including its specificity and, in particular, raising children.
- Data gathering from experimental trials (measurement of time, space, and velocity) and graphically representing and interpreting the collected results; determining the melting point of ice and boiling point of water; performing experiments to distinguish temperature and heat; experimentally demonstrating the existence of electrical charges and the difference between conductors and insulators; and performing experiments with magnets and iron filings.
- Classifying foods according to their nutritional ingredients; assessing the balance of one's nutrition and analyzing one's own nutrition lifestyle; explaining why pharmaceuticals, particularly anabolic steroids and psychotherapeutic drugs, should be taken only in case of need and under medical supervision; explaining why and how drug use, drinking alcoholic beverages, and smoking seriously damages one's health; and comparing the reproductive cycles of plants and animals, both invertebrates and vertebrates.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Time

The school year is 33 weeks, from September 1 to August 31. The school calendar is established by the local (regional) authorities and has a minimum duration of 200 days of lessons per year.[16]

In mathematics and science, primary schools can offer up to the current maximum of 40 hours per week of instruction. The minimum number of hours is 27 hours per week (approximately 891 compulsory hours of lessons per year) with the possibility of an additional 3 hours per week (the total number of additional hours per year is 99). Instead of a weekly schedule of lessons, there is a total annual number of hours that can be distributed throughout the year according to the autonomy granted to schools, which enables them to adapt their teaching time to educational needs.

In secondary schools in Italy, 4 hours of mathematics and 2 hours of science per week are devoted to the subject called mathematical, chemical, and physical sciences. Each school devotes specific time to the use of mathematics and science. In mathematics, the number of annual hours range from a minimum of 239 to a maximum of 251. For science, an average of 127 hours is devoted per year, including 33 hours devoted to technology annually.

Instructional Materials, Equipment, and Laboratories

Schools have a considerable amount and variety of teaching materials and are free to choose as they like. Likewise, teachers also can choose the relevant textbooks.

Grade at Which Specialist Teachers for Mathematics and Science Are Introduced

Specialist teachers for mathematics and science are available beginning in the first year of lower secondary school.

Use of Technology

Basic computer science is taught beginning in the first year of primary schooling—from using a computer for simple learning games (first year), to using basic procedures for graphic or iconic representation of language and simple sort and search algorithms (second 2-year period).

Secondary schools explore the use of information and communication technology in more depth, dividing between technology and computer science. With regard to technology, students go from building drafts or models, referring to everyday objects (2-year period), to using technical drawing for designing and creating models of general objects (third year). In computer science, students first use specific programs for presenting ideas and translating them into algorithms by means of a computer programming language (2-year period) to using a simple programming language for problem-solving, mastering the creation of hypertexts, and using networks (third year).

Teachers and Teacher Education

Education and Training for Fourth and Eighth Grade Mathematics and Science Teachers

The reform of the education system[17] in 2003 brought about great changes to the initial training of preprimary, primary, and secondary school teachers. Initial teacher training is to be carried out through specialist university degree courses associated with the different school levels. Currently, however, for teachers of preprimary and primary schools, training is carried out by attending the degree course in primary education sciences. For secondary school teachers, training is carried out by attending specific specialization schools. Admission to these specialization schools requires a university degree and an admission examination. The specialization school is divided into various tracks, each with many qualifying classes enabling participants to teach in specific kinds of secondary schools. Teachers who also wish to specialize in supporting students with disabilities receive additional training within their initial training. The university degree in primary education sciences and the specialization diploma for university graduates qualify teachers for teaching positions and constitute the basis for taking part in competitive examinations for teaching positions in preprimary, primary, and secondary schools. The specialization courses for future secondary school teachers also deal with in-depth studies of their own school subjects. There is a degree in mathematical and physical sciences for teaching mathematics and sciences. All initial training courses also focus on didactic activities concerning the integration of students with disabilities.

Examinations and Assessments

National or Regional Examinations

A final examination is administered upon leaving lower secondary school and a final examination upon completing the fifth year of upper secondary school. Periodic and annual student evaluations and the certification of skills acquired by students are entrusted to teachers, who also are responsible for student evaluations for moving on to the next year. In order to improve the quality of the education and training system, the National Institute for the Evaluation of the Education System was set up with the task of carrying out periodic and systematic checks on students' knowledge and skills and on the overall quality of the education or training offered by schools and training institutes. This institute has created a yearly survey on the Italian school population. In the 2005–2006 school year, it carried out a survey of all second and fourth year primary school students, first year lower secondary school students, and first and third year upper secondary school students for Italian, mathematics, and science. In the 2006–2007 school year, the annual survey of the same grades and for the same school subjects was carried out on samples of the population only.

At the eighth grade (lower secondary), the school itself prepares the mathematics and science examinations. At the 13th grade (upper secondary), the Ministry of Education prepares the mathematics and science examinations.

Monitoring Individual Student Progress

For each period of evaluation, every school autonomously drafts a student evaluation report on the student's progress in each sector of knowledge. In regard to student's having difficulties before the fourth grade, personalized study plans and remedial activities are carried out in class during normal lesson time. Before the eighth grade, the Ministry of Education has established personalized study plans and afternoon remedial courses with the student's own class teacher.

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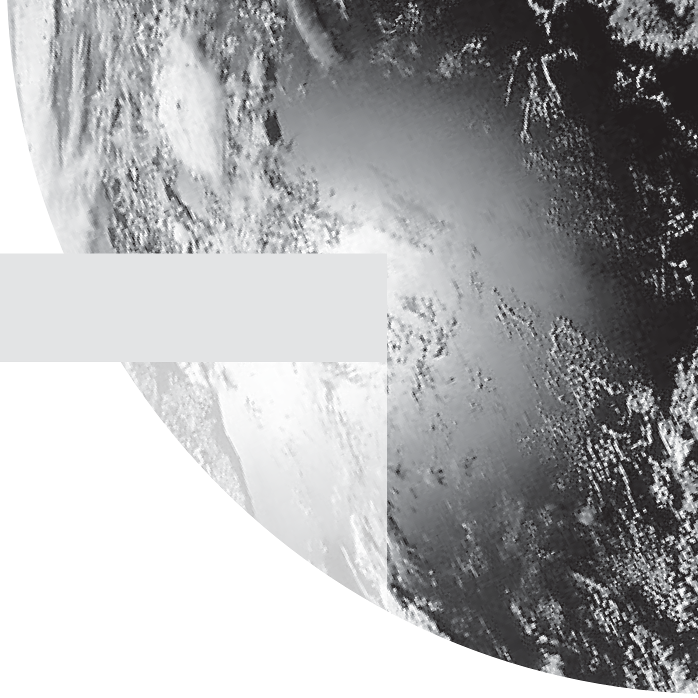

Japan

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Introduction

Overview of Education System

The Fundamental Law of Education[1] was compiled as the basis for post-World War II education in Japan and was enacted in 1947 and amended in 2006. The law stipulates the basic principles of education and provides equal opportunities for a free, compulsory education for 9 years. It is a law that forms the basis of all education-related laws, including the School Education Law[2] and the Social Education Law.[3]

The Ministry of Education, Culture, Sports, Science, and Technology is the administrative body responsible for school education, and all educational activities come under its supervision. Local bodies establish and maintain virtually all elementary and lower secondary schools and are responsible to a prefectural or municipal board of education. The ministry supervises and subsidizes local boards of education.

There are both public and private institutions at all levels of the academic hierarchy. The federal government bears most of the expenses of national schools, while municipal and prefectural schools are supported locally, with some assistance from the federal government. As a rule, private schools are self-supporting through tuition, donations, and support from businesses. However, national and prefectural governments do provide financial assistance toward maintaining and improving private schools. Eighty percent of kindergarten students, 1 percent of elementary students, 7 percent of lower secondary students, and 30 percent of upper secondary students are enrolled in private schools.[4]

Preschool education consists of nursery school and kindergarten. Nursery schools, for children ages 0 to 5, are not part of the official education system and are outside the supervision of the Ministry of Education, Culture, Sports, Science, and Technology. Instead, they are under the jurisdiction of the Ministry of Health, Labor, and Welfare. Kindergartens admit children ages 3 to 5. Programs are from 1 to 3 years. More than half of all 5 year olds are enrolled in kindergarten.

Education in Japan follows a 6-3-3 pattern and includes primary education in elementary schools and secondary education in lower and upper secondary schools.

Compulsory education consists of 6 years of elementary school and 3 years of lower secondary school. Almost all children between the ages of 6 and 15 are enrolled in school. In 2005, 98 percent of the age cohort entered upper secondary school, 89 percent graduated from upper secondary school, and 44 percent entered a university.[5]

In upper secondary schools, education can be full time, part time, or by correspondence. Full time students complete upper secondary school in 3 years, while part time and correspondence students take at least 4 years. About 97 percent of students in upper secondary schools were enrolled full time in 2005.[6] There are two streams at the upper secondary school level: general and specialized. About 73 percent of students in upper secondary schools were enrolled in general courses in 2005.[7] The specialized stream provides vocational and other education courses for students who have selected a future career. Courses include agriculture, industry, commerce, fishery, home economics, nursing, information, welfare, science and mathematics, physical education, music, art, and English.

In public elementary and lower secondary schools, there is no official policy on within-school streaming, and students are not tracked. From elementary to the end of lower secondary school, a compulsory program of mathematics and science is taught to all students in mixed-ability classes. The same curriculum is prescribed for all students.

Schools may offer several optional subjects beginning in grade 7, which interested students may take. At the upper secondary level, schools offer courses geared toward differing abilities and interests, and students are placed into tracks according to their entrance examination achievement level. In grades 11 and 12, several optional courses in mathematics and science are offered.

Under Japan's curricular reform, the courses of study (national curriculum) have been revised seven times since its implementation in 1947 to keep up with societal changes over the years and the needs of each age group. Also, in general, the number of class hours has been decreased. The goal of the sixth revision, implemented in April 2002 in elementary and lower secondary schools and in April 2003 in upper secondary schools, was to ensure that the courses of study reflect age-appropriate goals and the content corresponds to the qualities, capabilities, and knowledge that students will require for the future. As a result, in selecting specific educational content, emphasis has been placed on children firmly acquiring the basics and fundamentals of education and ensuring that content is more grade-level appropriate. Also, efforts were made to have children learn through experimenting and problem solving in cross-curricular topics, rather than through memorization and mere transmission of knowledge. In December 2003, minor revisions to the courses of study refocused learning on the individual needs of students. In 2011, the seventh revision will be implemented, changing the courses of study to focus on mathematics and science, as explained below.

Language and Population

Japanese is spoken by the overwhelming majority of Japanese people and, therefore, education is offered in Japanese. Recently, registered foreigners and foreigners with residency status have gradually increased and account for 2 percent of all residents in Japan.[8] In some regions (such as in Brazilian communities), education is provided both in Japanese and in Portuguese.

According to the most recent national census in 2005, the country's population had 127.8 million inhabitants.[9] The majority of the population consists of Japanese (98.5%). In addition, Koreans (0.5%), Chinese (0.4%), and other groups (0.7%) are recognized. Up to 200,000 Brazilians of Japanese origin migrated to Japan in the 1990s to work in industries.

Emphasis on Mathematics and Science

Since the 2002 school year, the ministry has designated some upper secondary schools that emphasize science, technology, and mathematics education as "super science high schools". The ministry researches and develops innovative curriculum that emphasizes science, technology, and mathematics education, with the goal of fostering promising scientists and engineers who will play a vital role in society. In the 2007–2008 school year, 31 upper secondary schools were designated as super science high schools.

Overarching Policies Related to Education and the Curriculum for Mathematics and Science

Under Japan's curricular reform, mentioned above, in the seventh revision of the courses of study, elementary schools in April 2011 and lower secondary schools in April 2012 will put more emphasis on mathematics and science education. As a result, the amount of content and class periods spent on mathematics and science will increase. This policy is influenced by results of international studies such as TIMSS and PISA; Japan is one of the top-level countries but not the top in the world in mathematics and science, and the level of positive attitudes toward mathematics and science are still low.

The Mathematics Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Mathematics Through Eighth Grade

The national standards for mathematics or arithmetic in elementary schools (*Sansuu*), mathematics in lower secondary schools (*Suugaku*), and mathematics in upper secondary schools (*Suugaku*) are prescribed in the courses of study.

The objectives and content of the mathematics curriculum are based on the course of study set by the ministry, and mathematics textbooks also are prepared in accordance with the course of study. Mathematics is a required subject throughout compulsory education as well, as in the first grade of upper secondary school.

Since 2002, for the first time in all levels of mathematics, mathematics activities have been introduced into the objectives of the curriculum. In addition, enjoyment of mathematics is described in elementary and lower secondary level objectives and fostering creativity is described in upper secondary level objectives.

The mathematics curriculum consists of three parts: objectives, objectives and contents in each grade (objectives, contents, and remarks concerning contents), and construction of teaching plans and remarks concerning content. Processes or methods and materials also are prescribed to some extent in the objectives and contents in each grade and in the construction of teaching plans and remarks concerning content. Also, the standard numbers of class periods per year for mathematics are prescribed in the general provision of the course of study for elementary school.

Mathematics content in grades 1 and 2 of elementary school is composed of the following three areas: numbers and calculations, quantities and measurements, and geometrical figures. In grades 3 to 6, in addition to these three areas, mathematical relations is added to the study of mathematics. At the lower secondary school level, the mathematics content is composed of three areas: numbers and algebraic expressions, geometrical figures, and mathematical relations.

All schools are obliged to address all points relating to the content of mathematics, and each school must formulate an overall plan for mathematics that includes descriptions of the following: objectives and content; qualities, abilities, and attitudes to be fostered; learning activities; teaching method and teaching framework; and a plan for the evaluation of learning.

The overall objectives for **fourth grade** in elementary school are to enable students, through mathematical activities concerning numbers, quantities, and geometrical figures, to acquire basic knowledge and skills, develop the ability to think systematically and logically in day-to-day events, become aware of the pleasure of carrying out activities, appreciate mathematical methods, and develop positive attitudes toward using mathematics in everyday life situations.

Specifically, the objectives for the content of grade 4 mathematics in elementary school are described below.

- Enable children to deepen their understanding of division and make appropriate use of it, enable children to understand the meaning of decimals and fractions and how to represent them, understand the meaning of adding and subtracting decimals, consider how to do these calculations, and use them appropriately.
- Enable children to understand the meaning of area, find the area of simple plane figures, and understand the meaning of the size of angles.
- Enable children to pay attention to the elements which compose figures and deepen their understanding of basic geometrical figures.
- Enable children to represent and examine quantities and their relationships using mathematical expressions and graphs, and, according to the purpose, investigate, classify, and organize dependent relationships.

The overall objectives and content for **eighth grade** in lower secondary school are to enable students to have an in-depth understanding of fundamental concepts, principles, and rules relating to numbers, quantities, figures, etc.; acquire methods of algebraic expressions and strategies, and improve their ability to examine phenomena mathematically; and enable students to enjoy mathematical activities, appreciate mathematical ways of approaches and thinking, and foster positive attitudes toward making use of them.

Specifically, the objectives for the content of grade 8 mathematics in lower secondary school are described below.

- Enable students to develop their ability to calculate and transform algebraic expressions depending on the intended purpose, enable them to understand simultaneous linear equations with two variables, and motivate them to use such equations.
- Enable students to deepen their understanding of the properties of basic figures through observation, manipulation, and experimentation and understand the significance and methodology of mathematical reasoning in terms of the properties of figures with a view to improve their ability to properly represent the deductive process.
- Enable students to understand linear functions through investigating concrete phenomena; increase their ability to discover, present, and examine functional relationships; and enable them to cultivate their basic way of thinking about probability through observation and experimentation about concrete phenomena.

The Science Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Science Through Eighth Grade

The objectives and contents of the science curriculum are based on the course of study set by the ministry. Textbooks also are prepared in accordance with the course of study, and science classes are conducted using these textbooks. Science instruction begins in the third grade and is a required subject throughout compulsory education.

The emphasis in the science curriculum is as follows. In elementary schools, with regard to the teaching of observations, experiments, plant cultivation, and animal rearing, appropriate devices such as computers or audio-visual equipment are selected, and students become practiced in manipulating them and learning how to use them. In lower secondary schools, as well as emphasizing observations, experiments, and outdoor observations, attention is paid to making full use of the local environment, given the actual location of each school and without imposing undue strain and to fostering a scientific approach to investigations of nature and the gradual formation of basic concepts.

The main changes in the science curriculum due to curricular reforms are as follows. In elementary schools, in the course of teaching, efforts have been made to visit museums, science learning centers, etc. As well as promoting subjective problem-solving activities in individual children, teachers enable children to use the outcomes of their learning to understand the natural phenomena in everyday life. In lower secondary schools, science content is determined based on the actual situation of the school and its locality and students.

Content in elementary school is composed of three areas: living things and their environment, matter and energy, and Earth and space. In lower secondary school, the content is composed of two fields: physical science and biology and earth science.

All schools are obliged to address all points relating to the content of science. Each school must formulate an overall plan for the science class period that includes descriptions of the following: objectives and content; qualities, abilities and attitudes to be fostered; learning activities; teaching methods and teaching framework; and a plan for the evaluation of learning.

The overall objectives for **fourth grade** science in elementary school are to enable children to become familiar with nature and carry out observations and experiments and identify a clear purpose. The objectives also include developing children's problem-solving abilities, nurturing the hearts and minds to be filled with a love of nature, and developing their understanding of natural phenomena and scientific views and thinking.

Specifically, the objectives for the content of grade 4 science in elementary school are described below.

- Enable children to explore familiar animal behavior and plant growth in relation to the seasons, and through investigative activities of problems based on their own interests and concerns, develop an attitude of love for living things and views and thoughts about animal activities and plant growth in relation to the environment.
- Enable children to explore state changes of air, water, and matter; the phenomena of electricity in relation to the function of force, heat, and electricity; and through activities such as investigating identified problems and/or making things with their own interests and concerns, develop views and thinking about the nature and functions of a matter.
- Enable children to explore changes in the position of the moon and the stars and changes in the state of water in the air in relation to time and the nature of water, and through investigative activities of problems based on their own interests and concerns, develop views and thoughts about the moon, the stars, and changes in the state of water.

The overall objectives for **eighth grade** science in lower secondary school are to enhance students' interest in nature, enable them to carry out observations and experiments, identifying a clear purpose, develop attitudes and abilities to investigate scientifically, deepen their understanding of natural phenomena, and develop scientific views and thinking.

Specifically, the objectives for the content of grade 8 science in lower secondary school are described below.

- *Electric current and its uses*: making observations and conducting experiments concerned with electric circuits; enabling students to understand the relationship between current and voltage, as well as the function of electric current; and developing elementary views and thinking about electric currents and magnetic fields in relation to everyday life.
- *Chemical change and atoms/molecules*: making observations and conducting experiments concerned with chemical change; enabling students to understand

the changes in substances, such as chemical combination and decomposition and the quantitative relationships involved; and develop views and thinking about the connections between these phenomena and models of atoms and molecules.

- *Life and kinds of animals*: making observations and conducting experiments concerned with familiar animals, understanding the structure of animal bodies and the functions of animals, and deepening students' recognition of different kinds of animals and how they live.
- *The weather and its changes*: making observations about familiar weather patterns, becoming aware of the regularity in weather changes, and deepening students' recognition of the regularity and the mechanisms related to the occurrence of weather phenomena.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Time

The school year begins April 1 and ends March 31. School holidays include national holidays, Saturdays and Sundays, and three long vacations. Most elementary and secondary schools are in session for 35 weeks or 190 days. Most schools adopt a three-term school year such as April 6 to July 20, September 1 to December 25, and January 8 to March 25, but some schools employ the two-semester system.

Most elementary and lower secondary students spend 6 hours per day in school from Monday to Friday. For most upper secondary students, school is 7 hours per day from Monday to Friday. School days from Monday to Friday include approximately 2 hours for lunch, assemblies, and other activities. Some public school students attend school from Monday to Saturday.

In elementary and lower secondary schools, the total number of class periods and the number and percentage of class periods that are spent yearly on mathematics and science are noted in Exhibit 1. A class period is 45 minutes in elementary school and 50 minutes in lower secondary school. For example, 105 class periods per year in eighth grade mathematics, as shown in Exhibit 1, equals 87 hours and 30 minutes. In that case, the percentage of class periods spent on grade 8 mathematics is approximately 11 percent. (In grades 1 and 2, life and environmental studies are taught instead of science and social studies.)

Exhibit 1 Yearly Instructional Time in Mathematics and Science in Japan by Grade

Grade	1	2	3	4	5	6	7	8	9
Class Period Totals	782	840	910	945	945	945	980	980	980
Mathematics	114	150	150	150	150	150	105	105	105
	15%	18%	17%	16%	16%	16%	11%	11%	11%
Science			70	90	90	90	105	105	80
			8%	10%	10%	10%	11%	11%	8%

Instructional Materials, Equipment, and Laboratories

The textbooks used either must be those authorized by the ministry or textbooks whose copyright the ministry owns. All mathematics and science textbooks are written and edited by several private publishers and approved by the ministry.

The ministry prepares and distributes a course of study[10, 11, 12] that forms a standard curriculum all textbooks must follow. Groups of cities or towns usually combine to form adoption areas in which a selection of textbooks for compulsory education is chosen. Municipal boards of education in adoption areas decide which textbooks should be selected on the basis of suggestions from school teachers. At the upper secondary levels, textbooks are selected by individual schools from those authorized by the ministry.

Grade at Which Specialist Teachers for Mathematics and Science Are Introduced

In the Japanese education system, the majority of elementary schools have classroom teachers who teach all subjects including mathematics and science, and almost all lower secondary schools have subject area specialist teachers for mathematics and science beginning in seventh grade. However, some private elementary schools and public elementary schools in some prefectures or cities have subject area specialist teachers for mathematics and science at the fourth grade.

Use of Technology

It is essential to cultivate children's ability to use information so they can respond independently to an advanced information communication network society. On the basis of the 2004 e-Japan Priority Policy Program Plan, all classrooms had to have access to computers and the Internet by 2005. Under the project, there now is a systematic effort to install computers for educational purposes, build or expand school LANs (local area networks), and have broadband Internet connections.

In regard to mathematics instruction, the curriculum contains statements about the use of calculators and computers. Calculator use is permitted beginning in grade 4 mathematics. The statement in the elementary school mathematics curriculum is as follows. "In teaching, soroban (abacus), calculators, computers and information communication networks may be used when necessary with care given to improving learning results. In particular, consideration should be given in this regard when carrying out instruction of the contents involving numerical calculation or instruction involving observation, manipulation, and experimentation."[13] Effective use of computers in mathematics is recommended both in elementary and lower secondary schools. However, use of computers in mathematics is rare at both school levels.

The science curriculum also contains statements about the use of computers and equipment. In elementary schools, appropriate devices, such as computers or audio-visual equipment are selected for use in teaching observations, experiments, plant cultivation, and animal rearing, and students become practiced in manipulating them and using them. In lower secondary schools, full and positive use is made of computers and telecommunication networks in science for information retrieval in the course of observational and experimental processes, the processing of experiments and data, calculations involved in experiments, etc.

Homework Policies

There is no government policy on homework.

Teachers and Teacher Education

Education and Training for Fourth and Eighth Grade Mathematics and Science Teachers

The success of formal education depends on the recruitment and placement of well-qualified teachers. Prospective elementary and secondary teachers must have a 4-year bachelor's degree, with several courses in education theory and pedagogy as part of their degree, and they must have the first-class teacher certificate. For example, to have the lower secondary school, first-class teacher certificate in mathematics, university students are required, as a minimum, to take 20 credits in mathematics, 31 credits in education theory and pedagogy, and 8 credits in either mathematics, education theory, or pedagogy. There are 2-year college courses in education, but graduates are awarded an associate bachelor's degree and receive the second-class teacher certificate. They may teach only at the elementary and lower secondary levels.

During teacher education programs, university students conduct a prepracticum in lower secondary school for several weeks, and their teaching is supervised by the school teacher.

To become a teacher, it is necessary to acquire a teaching certificate for a particular type of school, such as an elementary school, lower secondary school, or upper secondary school. In principle, the board of education for each prefecture or metropolitan district confers a teaching certificate to a graduate of a ministry-recognized university who has earned the required number of credits. In order to become a teacher at a public school, the individual who has earned a teaching certificate must then pass a selection examination offered by the prefectural board of education or designated municipal board of education. The examination is composed of paper tests, interviews, skill tests, essays, aptitude tests, etc. Thus, the board of education can make a comprehensive and overall judgment to determine the employment of a teacher. In order to be employed in a private school, an examination is not necessarily required.

Teacher Professional Development in Mathematics, Science, and Technology

After teachers are employed, they go through a broad spectrum of training implemented by their board of education. All newly employed teachers at public elementary and lower secondary schools undergo a year of induction training to cultivate practical leadership and a sense of mission as a teacher. In addition, a system was put in place in 2003 under which all teachers with 10 years of experience, according to their individual abilities and aptitudes, received training in topics such as course instruction and student guidance. The National Center for Teachers' Training and Education, an independent administrative corporation, provides various training courses for the purpose of educating administrators, principals, teachers, and other professionals in education and for addressing urgent issues. In addition, there also is a system that allows teachers at national and public schools to take a leave and study at a graduate school for the purpose of obtaining an advanced class certificate.

Additionally, professional development efforts are being made to promote teachers' instructional abilities, develop educational content that can be used in classrooms, and other learning activities to support the teaching and learning of technology use. Efforts also are being made to enhance the functions of the National Information Center for Education Resources, which is a website that provides educational resources in Japan for the use of information and communication technology.

Examinations and Assessments

National or Regional Examinations

Almost all prefectural boards of education administer the entrance examination to enter prefectural and municipal upper secondary schools at grade 9. In order to enter national, prefectural, municipal, and most of the private universities, the National Center for University Entrance Examination administers the entrance examination in several subjects, including mathematics and science in grade 12. However, examinations are not required for entry to any private upper secondary schools and some private universities. There is no examination to graduate from lower secondary and upper secondary schools.

Monitoring Individual Student Progress

Student progress in elementary and lower secondary schools is reported to parents in a report card at the end of each school term. In the report card, both norm-referenced and criterion-referenced evaluations are adopted in elementary and lower secondary schools. In mathematics and science, the following four points for criterion-referenced evaluations are used: interest/eagerness/attitude toward mathematics/natural phenomena, mathematical/scientific thinking, expression/processing, and knowledge/understanding.

Grade Promotion and Retention Policies

Grade promotion is automatic throughout compulsory education.

Suggested Readings

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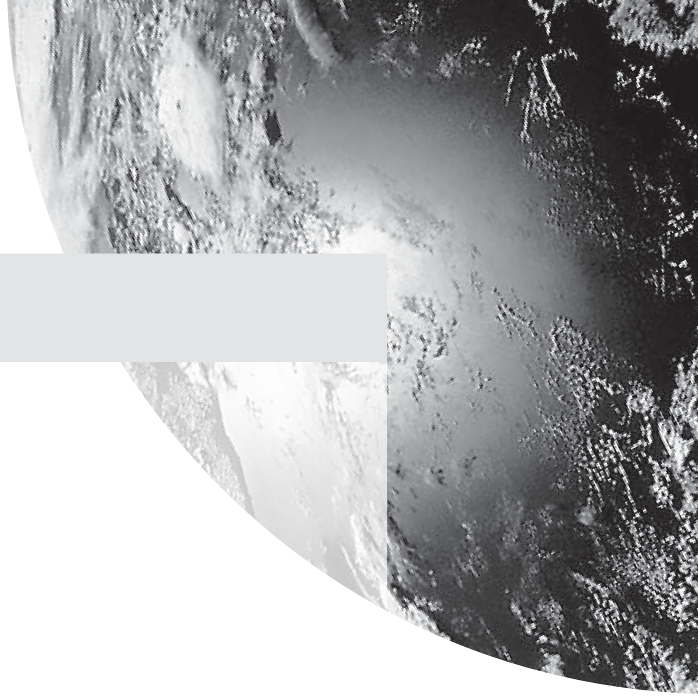

Jordan

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Introduction

Overview of Education System

Jordan's education system is concerned with preparing its citizens for future challenges and aspirations. This includes several developmental aspects, the most important of which is extending the compulsory, free, basic education cycle from 9 to 10 years.

One of the principles of Jordan's educational policy is ensuring that the education system is centralized in its general planning and follow up and decentralized in administration.[1]

In Jordan, the Board of Education in the Ministry of Education determines the curriculum. The ministry's monitoring, financial, and inspection divisions are responsible for following up on the auditing of the school system.[2,3]

The Ministry of Education, within its developmental plans, has been providing high-quality curriculum, textbooks, and teacher manuals that meet global standards and focus on the improvement of content and form, critical and creative thinking, problem-solving, linking content to life experiences, and helping students employ information in their academic and practical lives, in conformity with the requirements of the present era that is characterized by technical and scientific progress.

The structure of the education system consists of the following cycles.

- **Kindergarten**. This 2-year cycle is for children, beginning at age 4. It includes preschool and is noncompulsory. Schools are almost completely run by the private and voluntary sectors.
- **Basic education.** This is a 10-year cycle for children, beginning at age 6. In this compulsory cycle, the scheme of studies is unified for all students and evaluated annually. In addition, in grades 8–10, classification of students and their enrollment in the various types of secondary education is based on their marks.
- **Secondary education**. This 2-year cycle provides specialized cultural, scientific, and vocational experiences that meet the existing and anticipated needs of the Jordanian society. At the end of the 10th grade, students are classified into

two major streams: the comprehensive (academic and vocational) secondary educational stream and the applied secondary educational stream. The applied secondary educational stream provides vocational education and training for skilled labor to meet the needs of society. The first stream's program ends with the General Secondary Education Certificate Examination in the following specializations: an academic substream (including scientific and literary specializations) and a vocational substream (including industrial, commercial, agricultural, nursing, hotel management, and home economics).

The role of preprimary education is represented in the Ministry of Education's plans to expand and improve the quality of preschool education and encourage the private sector to establish kindergartens. The Education Reform for Knowledge Economy project is a government-supported effort to transform the education system at the early childhood, basic, and secondary levels in order to produce graduates with the skills needed for the knowledge economy. Component four of this initiative is concerned with promoting learning readiness through childhood education. The promotion of targeted approaches to improve the availability of early childhood education has been recognized as a high priority by the government and the Ministry of Education. Jordan wishes to make further inroads into the challenge of quality early childhood learning opportunities. The project will directly assist in the implementation of a comprehensive approach to improving the scope and quality of essential early childhood services.[4]

Within its capabilities, the Ministry of Education has established a number of kindergartens, particularly in remote and needy areas in order to achieve the following.

- Provide children with an adequate educational environment and care for well-balanced educational growth
- Help them acquire positive attitudes toward school for a smooth transition from home to school
- Develop good health practices
- Improve children's social relationships
- Enhance children's positive trends and love for school life.

Language and Population

The Arabic language is Jordan's official language, and it is the main medium of instruction. However, English and French are other languages that are commonly used and spoken in public and private schools in Jordan.

In the 2004–2005 school year, educational statistics indicated that the number of students enrolled in school was 1,522,700. The net enrollment rates were 96 percent in the basic cycle (for males, 96% and for females, 97%), 69 percent in the secondary cycle (for males, 68% and for females, 69%), and 32 percent in kindergarten (for males, 33% and for females, 31%).

Emphasis on Mathematics and Science

One of the educational projects of the Ministry of Education is developing and updating curriculum and focusing on achieving excellence in mathematics and science. E-math projects receive funding from the CISCO Learning Institute, and e-science projects are funded by the private sector, specifically the Fastlink Corporation. Jordan also participated in TIMSS 1999, TIMSS 2003, and TIMSS 2007, in order to measure eighth grade student achievement in mathematics and science. In TIMSS 2003, 140 Jordanian schools and 4,489 students participated.[5] The results indicated that in science, Jordan ranked first among Arab countries and 26th internationally. In mathematics, it ranked second among Arab countries and 33rd internationally.[6]

The Mathematics Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Mathematics Through Eighth Grade

Jordan went through several education reforms since 1989 in which the curriculum was a major component. In the latest project, Education Reform for Knowledge Economy, the new curriculum was revamped to focus on learning outcomes and knowledge skills. As a result, new textbooks in mathematics were produced for all grades and supplemented with e-content.

In terms of content, it is expected that all students master the mathematics curriculum in the following dimensions: numbers, algebra, geometry, measurement, and probability and statistics. Students need to show competency in the following cognitive domains: knowing, applying, and problem-solving, in addition to mastering well-defined skills for the knowledge economy such as communication; information management; using symbols, figures, and graphs; and solving problems in real-life situations. The expectations for students in the basic cycle, grades 1–10, are described below.

- *Numbers*: demonstrate knowledge of place value and the four operations; solve problems by computing, estimating, or approximating; and compare and order fractions and decimals.
- *Algebra*: evaluate expressions for given numeric values of the variables; simplify or compare algebraic expressions to determine equivalence; model situations using expressions; evaluate equations or formulas given values of the variables; solve simple linear equations and inequalities; recognize and write linear equations and inequalities, and solve problems using equations or formulas and functions.
- *Geometry*: recognize relationships between three-dimensional shapes and their two-dimensional representations, use visual and spatial inference to solve problems, and apply geometric transformation and symmetry to analyze mathematical problems.
- *Measurement*: understand the features of measurable forms, measurement systems and operations and apply techniques, tools, and formulas to determine the appropriate measurement.

- *Probability and statistics*: organize and display data using tables, pictographs, bar graphs, pie charts, and line graphs; recognize and describe approaches to organizing and displaying data that could lead to misinterpretation; and use data from experiments to predict the chances of future outcomes and formulate questions that require appropriate data collection.[7]

The Science Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Science Through Eighth Grade

The three most recent major education reforms also focused on the enhancement of the science curriculum. In 2003, Jordan started a phased-in comprehensive approach to improve the scope and quality of the science curriculum. In 2006, a new science curriculum was introduced for grades 1, 4, 8, and 10, and a year later for all other grades.

For grades 1–8, there is an integrated curriculum, and in grades 9 and 10, science is taught as four separate subjects: biology, chemistry, physics, and earth science. The expectations for students in these grades are described below.

- *Force and movement*: acquire concepts, facts, and basic principles of force and movement and understand their relationship; use laboratory equipment and instruments to explore concepts and facts and various scientific measurements; follow security rules and procedures for public safety in the class, school, and laboratory; and use oral and written communication skills and mathematical and physical representations to describe scientific concepts related to force and movement.
- *Matter and energy*: acquire concepts, facts, and basic principles related to the concept of matter and energy; ensure faith in God through the foresight of the universe and understand that its materials have significant impact on our lives; investigate by researching and using scientific thinking; use laboratory materials and tools to explore scientific knowledge; and use security rules and procedures in the laboratory, class, school, and home.
- *Organisms and their environments*: show understanding of the characteristics of living organisms and their needs, life cycles, relationship with each other and with their environments, and demonstrate knowledge and skills necessary to understand the nature of the human body and maintaining one's health.
- *Meteorology*: understand the components and characteristics of the atmosphere and its interaction with other land covers.
- *Terrestrial materials*: understand the components and characteristics of the land and the Earth's water and its interaction with other land covers, as well as the human impact on it.
- *Astronomy*: understand the components of the universe, its characteristics and origin, and its regulations.
- *Earth's history*: describe the changes experienced by the Earth.

- *Geological processes*: understand geological processes and their role in the formation of topographic features and geological phenomena.
- *Oceans*: understand that the oceans are a complex, dynamic system in which exchanges between natural systems, chemicals, and weather occurs.[8]

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Time

For grades 1 to 10, mathematics makes up 15 percent of the school instructional time. Students study mathematics five periods a week and each period is 45 minutes. For grades 1 to 8, science is three to five periods per week, and for grades 9 and 10, it is seven periods per week. Specifically, in grades 1–2, science is three periods per week; in grades 3–7, it is four periods; and in grade 8, it is five periods per week.

In grades 9 and 10, physics, chemistry, and biology are allocated two periods each week and earth science is allocated one period per week. In each grade, 10–19 percent of school instructional time is allocated to science. Generally speaking, about 13 percent of the time in school is dedicated to science.

Instructional Materials, Equipment, and Laboratories

The ministry provides lists of equipment and laboratory tools in order to fulfill the requirements mentioned in the school curriculum. These lists are updated regularly and aligned with the curriculum. Some of these tools and equipment are purchased, others are manufactured locally. They are distributed to schools, and the ministry receives feedback to modify and update school laboratories. Since the ministry emphasizes decentralization, schools allocate a portion of the school budget to purchasing some materials and equipment.

Schools have good quality materials and equipment to present better instruction to all students in grades 7 to 12. Age-appropriate curriculum materials and equipment are used to implement effective teaching. An inventory review of all equipment is performed on a regular basis to ensure that materials remain updated and equipment and tools are in good condition.

Use of Technology

The ministry has integrated a comprehensive project for educational reform (i.e., Education Reform for Knowledge Economy), supported by both local and official sectors and donors abroad. In a knowledge economy, the ability to use information and communication technology is one of the essential requirements, and it is one of the foremost tools for acquiring information, communicating with others, and developing new ideas.

Many schools in Jordan have high-speed connectivity and access to the Internet, and students and teachers are able to take advantage of the technology in a variety of ways applicable to many subjects (e.g., English, Arabic, mathematics, science, and civics).

Some examples of the use of technology in schools in Jordan as a learning tool include the following.

- Using the online material provided for students and teachers at the ministry portal (e.g., science, mathematics, ICT, and English)
- Accessing information on the Internet
- Creating graphs from data
- Using educational software
- Developing multimedia presentations
- Searching for references on a CD-ROM encyclopedia.

In addition, there are many professional development programs for teachers, supervisors, and seniors such as the International Computer Driving License, Intel's Teach to the Future, and WordLinks. The goal of Intel and WordLinks is to train teachers on how to encourage project-based learning.

To support the needs of a variety of learning styles, the ministry has developed a 3-year project called Knowledge Centers to enhance the student-centered approach. It will create a new kind of school library called a "knowledge center". Each knowledge center has received the financial support to create within the school a center with seating and study spaces for students. Each center also includes open access shelving for books, newspapers, magazines, audio and video tapes, CDs, DVDs, computer software, etc., so that it is a pleasant and welcoming environment for both students and teachers.

Teachers and Teacher Education

Education and Training for Fourth and Eighth Grade Mathematics and Science Teachers

The Ministry of Education in Jordan recognizes that improving the quality of education is a priority for the nation's development and an ultimate goal to be achieved. Developing the quality of teacher education through the progressive reform of education policies and strategies and the quality of training are important tools to achieve this goal. The decision-makers in the ministry believe that the Jordanian education system must prepare and qualify young people to be critical thinkers who acquire life skills in a changing world.[9]

Thus, in 1999, Jordan was one of the 38 countries that participated in TIMSS 1999. Taking into consideration that the most significant purpose of this test is to help students improve their performance in mathematics and science, information about student performance on TIMSS was collected and analyzed under the supervision of the National Center for Human Resources Development and in coordination with the IEA and the educational organizations in Jordan. The student responses were studied thoroughly and the decision was made to prepare guides to train teachers.

Jordan also participated in TIMSS 2003 to determine students' knowledge and skills in mathematics and science. The results were analyzed and teachers were made aware of common student errors. Again, recommendations based on this analysis were utilized in preparing teacher training guides. These training guides include the following.

- Identification of students' errors on the assessment, their types, and how these errors occurred
- Suggested questions and tasks that may help students become aware of how errors occur
- Suggested learning strategies, such as remedial tasks, which might help students deal with errors.

One of the urgent needs of the Jordanian education system is to have highly qualified, competent teachers who acquire certain competencies. Therefore, the ministry has responded to this requirement through the implementation of the Education Reform for Knowledge Economy initiative (mentioned previously). Component two of this program is designed to transform educational programs and practices that support the knowledge economy. The key directions in this area are improved professional development and training and improved learning resources. Thus, some of the specific requirements to teach mathematics and science are the following.

- A specific program for the teachers of mathematics and science in the area of preservice to prepare teachers before they enter into the field
- Teacher professional development, which will be taken into consideration in teacher certification
- Closer coordination with the faculties of education to satisfy the needs of the ministry in preparing competent mathematics and science teachers.

In conclusion, the efforts of the Directorate of Training, Qualification, and Supervision are concentrated on providing information to foster areas of strength and avoid areas of weakness in order to help Jordanian students become innovative thinkers who can build their community and participate in the development of the international community. Furthermore, building quality assurance mechanisms into the education system is an important component of these initiatives.

Teacher Professional Development in Mathematics, Science, and Technology

The implementation of the Education Reform for Knowledge Economy initiative presents different opportunities to address some of these training issues, which are listed in the section above. Teacher competencies are being developed, and a comprehensive teacher professional development plan is being prepared.

Examinations and Assessments

National or Regional Examinations

The Directorate of Examinations and Tests administers and conducts a number of examinations and tests that fall under two main categories: the General Secondary Certificate Examination and national testing. The General Secondary Certificate

Examination has nine different versions (academic and vocational) for those who have finished 12 years of schooling. The different versions have five common core subjects, plus some other subjects for specialization assigned to each version. High stakes are attached to these examinations, since their results are used for higher education admission purposes. The second category, national testing for grades 4, 8, and 10, includes testing in a variety of subject areas. The purpose of the national tests is to monitor and evaluate student performance in relation to the learning outcomes prescribed in the National Curriculum. The national tests will begin to align with the goals and learning outcomes of the new National Curriculum that is being implemented at grades 1, 4, 8, and 10 during the 2005–2006 school year. Another goal of the national tests is to provide schools and regions with data that can be used to improve student performance.

At the national level, the National Center for Human Resources Development also conducts the National Assessment for Knowledge Economy Skills.

The main assessment activity administered by the Directorate of Examinations and Tests is the diagnostic assessment, which is conducted annually for grades 5 and 9 in science, mathematics, English, and Arabic. The purpose of this assessment is to improve instruction and learning through prescribing remedial tasks. The assessment is administered to a sample of the whole student population. The Directorate of Examinations and Tests is now in the process of designing a new assessment, the Knowledge Economy Assessment. The subject areas science, mathematics, and reading will be tested for the purpose of monitoring overall student progress in relation to critical knowledge economy skills.

The Directorate of Examinations and Tests also is in the process of developing standardized tests. On a regular basis, items from all subject areas are stored in item banks after undergoing regular scientific procedures. However, private schools are free to purchase commercial tests when required.[10]

Other Tests

TIMSS provides information at two levels: regional (between Arab countries) and international. Jordan also participated in PISA.

Monitoring Individual Student Progress

The assessment policy is updated to ensure that classroom assessment practices conform with the Education Reform for Knowledge Economy project, which puts the student at the center of the learning process and focuses on each student's development as a responsible person and citizen of the knowledge economy. A set of assessment strategies and tools are developed and used to monitor individual student progress. Among these strategies and tools, performance-based assessment, observation, communication, reflection, checklists, rubrics, and learning logs are used to enable the teacher and students to achieve the above-mentioned goals. These strategies and tools are used to gather information about student progress and generate grades, which are recorded, in addition to the grades collected from pencil and paper tests. New report cards have been designed to facilitate the new reporting system that focuses on basic skills and general learning competencies. Additionally, parents obtain information that may help them for future planning.[11]

Grade Promotion and Retention Policies

According to the regulations issued by the directorate, students in grades 1–3 are promoted automatically unless a student gets less than 40 percent in mathematics and the Arabic language. Students in grades 4–10 are promoted automatically as well, unless a student fails in four subjects. If a student fails in three subjects, then he or she sits for a make-up examination. The passing mark is 50 percent. Students are promoted even if they fail the make-up examination after two retentions during the basic stage, grades 1–10. Acceleration of students is possible after careful assessment, special tests, and interviews to ensure students' capability. However, this can not exceed two grades. Regarding the secondary stage, promotion and retention is course based, and students may sit for any individual test more than once to fulfill the requirements of the General Secondary Certificate Examinations.[12]

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Kazakhstan

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Introduction

Overview of Education System

According to the Constitution of the Republic of Kazakhstan,[1] the state guarantees a free and comprehensive secondary education for its citizens. In Kazakhstan, secondary education includes three integrated levels—primary, lower secondary, and upper secondary education (grades 1 to 11). The Kazakhstan school system of secondary school is significantly centralized in regard to the administration of the education system, but it is decentralized in its practice of financing schools.[2]

The Ministry of Education and Science is responsible for allocating financial resources of the republic's budget to operate the public education system and carry out normal maintenance of the schools. Financing of the education institutions is defined according to their legal status: state and nonstate. The state education institutions are financed by the republic and local budgets. Almost all primary and secondary institutions of education in Kazakhstan are state institutions (7,928 of 8,055 in the 2006–2007 academic year). The local budget is the main source of funding (covering about 80% of educational expenses).[3]

In accordance with the Law of Education, secondary education is regulated by two main instruments, the State General Standards of Education[4] and the ministry's academic programs.[5] The standards define the minimal and obligatory education requirements for students.

The government of the Republic of Kazakhstan develops and carries out government policy on education and approves state programs of education, as well as strategic plans for developing the education system. The Ministry of Education and Science directly implements measures on developing state programs, establishing the basic components of the state educational standards, creating the models of standard education plans, and establishing the standard academic educational curriculum. Also, they develop examinations and publish textbooks and subsidiary literature for schools.

On the basis of the standard educational programs, each education institute develops the curriculum in each of the separate subject areas, an annual academic calendar, and schedule of lessons.

Preprimary education is provided for children ages 1 to 6, but is only compulsory for ages 5-6. Preprimary education is provided by the family and in preprimary institutes and prepares children for secondary education.

Secondary education includes the following three levels.

- **Primary education**, grades 1 to 4, is provided in primary schools, in lower secondary schools, which include the primary level, or in secondary schools, where there are all three levels of secondary education. The goal of primary education programs is to form a child's personality; develop his or her individual abilities; develop good skills in reading, writing, counting, and language communication; encourage students' self-realization; and teach behavior that will help them master subsequent school programs in lower secondary education.
- **Lower secondary education,** grades 5 to 9, is focused on helping students master the foundations of science systems and form interpersonal and interethnic communication, personal self-definition, and a vocational orientation.
- **Upper secondary education,** grades 10 and 11, is focused on educational content and vocational orientation.

Language and Population

The state language in the Republic of Kazakhstan is the Kazakh language. Russian also is used officially in the state institutions and local authority institutions.

Kazakhstan is a state with a multiethnic population. Representatives of more than 120 nationalities live in the republic. Kazakhs comprise 58.7 percent of the inhabitants, Russians, 27.9 percent, and Ukrainians, Uzbeks, Germans, Tatars, Uighurs, and other nationalities together make up 13.3 percent of the inhabitants of Kazakhstan.[6]

Second-language Instruction

Most schools provide instruction in the Kazakh and Russian languages. However, there are 90 schools that provide instruction in the languages of ethnic groups so that students have the opportunity to learn their mother tongue. There also are mixed schools, which provide instruction in two or three languages.

Parents may choose the language of instruction for their children. Children of Kazakh nationality generally study in the Kazakh language, while children of different nationalities (e.g., Russians, Kazakhs, Uighurs, Uzbeks, Koreans, etc.) generally study in Russian.

Emphasis on Mathematics and Science

Providing a high-quality education in mathematics and science in Kazakhstan is a priority. In this regard, the government annually assigns significant financial resources to the acquisition of multimedia classrooms, improvement of the materials and technological resources of schools, the training and improvement of teachers' qualifications, and the updating of textbooks.

Achievement of students in mathematics and science is annually monitored by the National Center of State Standards and Tests through the Intermediate State Control, with a representative sample in grades 4–9 and the Unified National Test for all 11 grades. The results of both these assessments are analyzed by the National Center of Assessment of Education Quality.

The Mathematics Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Mathematics Through Eighth Grade

The purposes, tasks, and objectives of mathematics at the primary, lower, and secondary levels of secondary school are described in the State General Standards of Secondary Education. Mathematics content for **grades 1 to 9** is detailed below.

- *Grades 1–4*: the concept of natural numbers and their use; skills in oral and written calculations with natural numbers and zero; experience making arithmetic task decisions; practical tasks of decision-making; initial experience with geometric activities related to geometric figures and measuring geometric shapes; and skills relating to explaining one's own actions and appropriate speech skills and learning to use the main terms and symbols in mathematics.

In the lower level of secondary school, mathematics is studied in two stages.

- *Grades 5–6*: the concept of numbers and the role of calculation in everyday life; the concept of statistical characteristics; practical skills in calculation; and writing number sentences.
- *Grades 7–9 (algebra)*: calculating skills; formal operations in algebraic skills; capacity and drawing of elementary functions; functional-graphic concepts used for description and analyses of functional relationships; notions of studying concepts and methods as important ways of mathematical modeling of real processes and phenomenon; logical thinking and speech skills to support one's opinion, carrying out simple systematization, and use of different mathematical languages (verbal, symbolic, and graphic).
- *Grades 7–9 (geometry)*: systematized information about geometric figures, including 2-D shapes, and experience using analytic apparatuses to make geometric task decisions.

The content of mathematics is traditionally built around the following components.

- *Numbers and calculations*: natural numbers, ordinary and decimal fractions, percents and proportions, whole numbers, rational numbers, the concept of irrational numbers, real numbers, order ratio, arithmetic actions and their capacities, calculation algorithms, raising a number to a power and finding the square root, number logarithms, sine, cosine, tangents of numeral argument, and approximate calculations.

- *Mathematical expressions and their transformations*: quantity variables, letter and number expressions, and equal expressions and their use for the transformation of expressions; algebraic expressions (monomial, multimodal, fractions), arithmetic actions with the whole and fraction algebraic expressions; and degree, logarithmic, and trigonometric expressions.
- *Equations and inequalities*: the proof of equations and inequalities; the equal strength of equations and inequalities; identifying equations and inequalities; equations and inequalities with one and two unknowns and their geometric interpretation; rational inequalities; systems and the totality of equations and inequalities; and general methods and ways of solving equations, inequalities, and systems.
- *Functions*: numerical and elementary functions, their qualities and graphics; derivatives; prototypes; integrals; and arithmetic and geometric progressions.
- *Geometric figures and dimensions of geometric value*: geometric figures and their qualities (point, segment, beam, straight line, 2-D shapes, multi-angles, circumference of a circle, polyhedrons, bodies of rotation, etc.); geometric relationships; geometric values (length of lines, value of angles, area, and volume); vectors and coordinates; and applying algebraic and analytical apparatuses in geometry.
- *Elements of probability theory and statistics*: ways of presenting statistical data (tables, diagrams, polygon), statistical characteristics (mode, median, average), graphics of real processes, calculation of variance, systematic sorting out, permutation, placing, combinations, and geometric models.

The Science Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Science Through Eighth Grade

Science in **grades 1–4** is realized through an integrated course called "knowledge of the world", which includes the study of the following areas: nature, humans, and society.

- *Nature:* living and nonliving things and their attributes; phenomena of nature and their attributes, qualities, and mutual connections; and the animal and plant world and their common features, basic needs, and surroundings.
- *Humans*: the concept of humans as a part of natural phenomena, significant features that differentiate humans from animals, the role of humans in the development of science, technology, and the environment and society.
- *Society*: the motherland, family, school, and understanding yourself and your position in society.

The contents of each subject are studied continuously from the first to the fourth grades and subsequently become more complex from grade-to-grade.

In lower secondary education, **grades 5–9**, the natural sciences are made up of the following subjects: geography, biology, physics and astronomy, and chemistry.

- **Geography** is studied in grades 5 to 11. By the end of the ninth grade, students should have knowledge about Earth as one planet of the solar system; Earth's size and form; the variety of continents; the main problems of modern geography, environmental problems, and problems of nature; natural features of the Earth that reflect its structure, space, and differences; processes and phenomena on Earth; material and spiritual cultural values and the experience of knowledge and human existence in space; the type, structure, and characteristics of territories; the modern world and concepts relating to its stable development and variety; and global, regional, and local problems of humanity and ways of solving these problems.
- **Biology** is studied in grades 6 to 11, from the molecular to biosphere levels and includes the molecular, cellular, tissue, organism, population, biogenetical, and biosphere levels of life organization; the variety of living organisms, their interaction, ontogenesis, phylogenies, and evolution; systemic groups of organisms; a human as a biosocial person; fundamental biological theories (cellular, evolutionary, chromosome), and boundary concepts (ecology, the origin of life, etc.). Specifically, in grades 6 to 9, students study living organisms, the variety of organisms, evolution, selection, and the environment of fauna and flora; humans and their health; the biology of the cell; the basis of genetics and natural selection, including heredity and human genetics; the basis of evolution; the basis of ecology; and the biosphere.
- **Physics and astronomy**, in grades 7 to 9, focuses on the physical methods of studying nature; mechanics; molecular physics and thermodynamics; electrodynamics; atomic and nuclear physics; and astrophysics.
- **Chemistry,** in grades 8 to 11, focuses on the different levels of substance organization; simple and complex substances; pure substances and mixed ones; basic classes of organic and inorganic substances; natural and chemical polymers; the theory of the chemical construction of substances; chemical reactions and their classifications; the periodic system of chemical elements; and the theory of electrolytic dissociation. Specifically, by the end of grade 9, students study the atomic-molecular theory and the law of substance and weight conservation; physical and chemical phenomena, their construction and occurrence; chemical elements and formulas, including atomic and molecular masses; oxygen, hydrogen, and water; the main classes of periodic bonds, the periodic system of chemical elements, covalent and ionic chemical connections, electrolytic dissociation of acids, foundations, and salts; physical and chemical qualities of metals and nonmetals; and original concepts of organic bonds.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Time

The school year begins on September 1 and consists of 34 weeks of study (204 days). Schools use a 6-day schedule, except in grade 1, where a 5-day schedule is allowed. According to the curriculum, students in first grade are in school 13 hours per week; in second grade, 18 hours, and in third and fourth grades, they attend school 20 hours per week. In the fifth and sixth grade, students attend school 23 hours a week; in the seventh grade, 24 hours; in the eighth grade, 27 hours, and in grades 10 and 11, students are in class 29 hours per week. Each lesson lasts 45 minutes, except in first grade, where the lessons are shorter (35 minutes).

In fourth grade, students have five mathematics lessons and two science lessons per week, which is 18.5 percent and 7.5 percent, respectively, of the total instructional time. In eighth grade, students have four mathematics lessons per week (about 12%) and in the natural sciences, students have two geography lessons, two biology lessons, two physics lessons, and three chemistry lessons per week. In total, in eighth grade, 26.4 percent of total instructional hours per week are spent on science.

Instructional Materials, Equipment, and Laboratories

After the reform of education in 1991, in accordance with the State Comprehensive Standards of Education, the textbooks and curriculum in all school subjects were revised. Instruction in primary school is now carried out with revised and reworked editions of these textbooks. The list of educational editions allowed for use in school is defined by the Ministry of Education and Science. Realization of the program in mathematics and natural science subjects is carried out in specially equipped classrooms, which are supplied with necessary educational equipment and visual aids.

In the lower and upper secondary school levels (grades 5 to 11), instruction in mathematics and science is carried out according to standard requirements in specially equipped classrooms.

Educational materials, including those related to technology, are determined by the school administration and local organizations that have educational control. Along with basic textbooks recommended by the Ministry of Education and Science, alternative textbooks are used. Teachers choose materials in accordance with their professional preference, students' characteristics and interests, and parents' opinions. To help them in choosing the educational program and attendant materials, the ministry prepares a description of different educational programs and requirements in regard to their contents. In the description, details about the materials and how they differ according to the teaching methods and class level are included.

Grade at Which Specialist Teachers for Mathematics and Science Are Introduced

In most educational institutions in Kazakhstan, there are separate specialists teaching mathematics and science beginning in fifth grade. However, in primary school, all subjects are instructed by one teacher who also is a class tutor.

Use of Technology

According to the state program of information on the secondary education system, access to technology is provided to schools and teachers receive technology training. Computers in education institutions use new information technologies for instruction, as well as for administration of educational processes, and infrastructure is being developed to support technology in all education institutions. Secondary education personnel are being introduced to new technologies and are constantly being trained and retrained on how to use information technology.

Also, there is a program that supplies schools with multimedia classrooms, where students learn Kazakh, Russian, and foreign languages. Almost all the schools—95 percent—are connected to the Internet.

Multiservice Informational Net, a project by the Ministry of Education that is being carried out between 2007–2009, provides widespread, unlimited school access to the Internet.

Homework Policies

There are no rules on assigning homework tasks in mathematics and science in the fourth and eighth grades. Nevertheless, homework in these subjects is given after each lesson. Recommendations about whether to assign separate homework tasks are given in each program.

Teachers and Teacher Education

Education and Training for Fourth and Eighth Grade Mathematics and Science Teachers

There are several different ways to become a primary school teacher. Teachers must be educated at higher education institutions in a 4-year bachelor's degree program that confers a Bachelor of Pedagogy and Methods of Primary Education. Two-year study programs for secondary school graduates or 4-year programs for lower secondary school graduates also are offered at pedagogical colleges. Those who receive a qualification as a primary school teacher at a pedagogical college usually continue their education.

To become a teacher of mathematics, geography, physics, biology, and chemistry in grades 5 to 11, it is necessary to get a higher education degree from a 4-year bachelor's program and obtain a bachelor's degree.

In order for students to complete the Bachelor of Education process, they must master the following.

- *Pedagogy and methods of primary education*: 5,760 academic hours of theoretical studies (including research work, practical work, laboratory, and coursework); 1,035 hours of professional practice; 3,645 hours of a compulsory curricular component; and 2,115 hours of an elective curricular component.
- *Mathematics*: 5,760 academic hours of theoretical studies; 630 hours of professional practice; 3,735 hours of a compulsory curricular component; and 2,025 hours of an elective curricular component.
- *Geography*: 5,760 hours of theoretical studies; 525 hours of educational field practice; 3,420 hours of a compulsory curricular component; 2,340 hours of an elective curricular component; approximately 480 hours of professional-pedagogical practice; and 360 hours for the writing and defense of diploma work.

- *Physics*: 5,760 hours of theoretical studies; 270 hours of professional practice; 3,510 hours of a compulsory curricular component; 2,250 hours of an elective curricular component; and 180 hours for the writing and defense of diploma work.
- *Biology*: 5,760 hours of theoretical studies; 2,205 hours of professional practice; 3,375 hours of a compulsory curricular component; 2,385 hours of an elective curricular component; and 180 hours for the writing and defense of diploma work.
- *Chemistry*: 5,760 hours of theoretical studies; 810 of professional practice; 3,645 hours of a compulsory curricular component; 2,745 hours of an elective curricular component; and 270 hours for writing and defense of diploma work.

The curriculum for primary education teachers in mathematics, geography, physics, chemistry, and biology for each higher education institute is worked out on the basis of state standards for higher education[7] and includes the curriculum, instructional programs for all subjects and courses, and programs of teaching practice in schools.

Teacher Professional Development in Mathematics, Science, and Technology

Every 5 years, teachers improve their qualifications and are retrained at universities, where they obtain professional knowledge, improve their teaching skills, and realize their creativity in the profession. Qualification improvement and retraining of educational personnel is compulsory for teachers.

The modern system of teacher qualification improvement in Kazakhstan, offered as one course, cycled courses, seminars, and conferences, is realized in the following forms: self-education of teachers, methodical units, chairs, and centers within the framework of educational institutions.

Examinations and Assessments

National or Regional Examinations

Annually, the Ministry of Education and Science issues an order and assigns examinations in mathematics for students graduating from grade 9 (lower secondary school) and grade 11 (upper secondary school). In grade 11 mathematics, students choose either a state examination in an educational institution or the Unified National Test (UNT), a nationwide standardized examination in a test center.

In grades 5 to 8 and in grade 11, students take promotion examinations in two subjects, which annually are determined by educational institutions. Students also take the UNT. This examination was introduced in 2004 for four subjects: three are compulsory (mathematics, the language of instruction, and the history of Kazakhstan), and one subject is chosen according to a student sampling. Students must pass the UNT, as it is one of the final assessments of student achievement in secondary schools. Depending on the results of the UNT, students receive a certificate of secondary education and a certificate with the UNT scores. Results on the UNT are used in addition to entrance examinations to universities to determine whether students will continue on to higher education.

Additionally, the Intermediate State Control assesses the effectiveness of the curriculum in grades 4 to 9, which is carried out in the form of an independent test for educational institutions.

Monitoring Individual Student Progress

Monitoring investigations take place at each educational institution to evaluate curriculum implementation. Teacher evaluation of students in the classroom is carried out through quizzes, final examinations, and evaluation of students' individual work.

Monitoring investigations are carried out to compare student achievement with curriculum requirements and provide diagnostics of student progress. Sometimes, the results of investigations are used by teachers during the accreditation of schools. Monitoring investigations usually are carried out at the end of each school year and in each subject. The form of the investigation includes oral examinations, short answers, extended-response answers, and multiple-choice tests. Schools usually use tests written by their teachers, local organizations, or those provided centrally and published as special auxiliary materials.

Grade Promotion and Retention Policies

According to the Regulations About Intensive Education, student promotion is dependent on academic achievement. There are special rules for promotion and repeating grades 1 to 8. Students in the primary and lower secondary education levels who have not mastered the program in the school year in three or more subjects are not promoted to the next grade. Students in the first grade can be kept in the same grade under the recommendation of the Medical-Pedagogical Commission and with the agreement of parents.

Students in the primary and lower secondary education levels who have not passed one to two subjects by the end of the school year are promoted to the next grade after having completed summer tasks and passing examinations. Students in grades 1 to 4 must successfully master the educational program in order to be promoted to the next grade. Students in grades 5 to 8 and in grade 10 must pass examinations to be promoted to the next grade.

Suggested Readings

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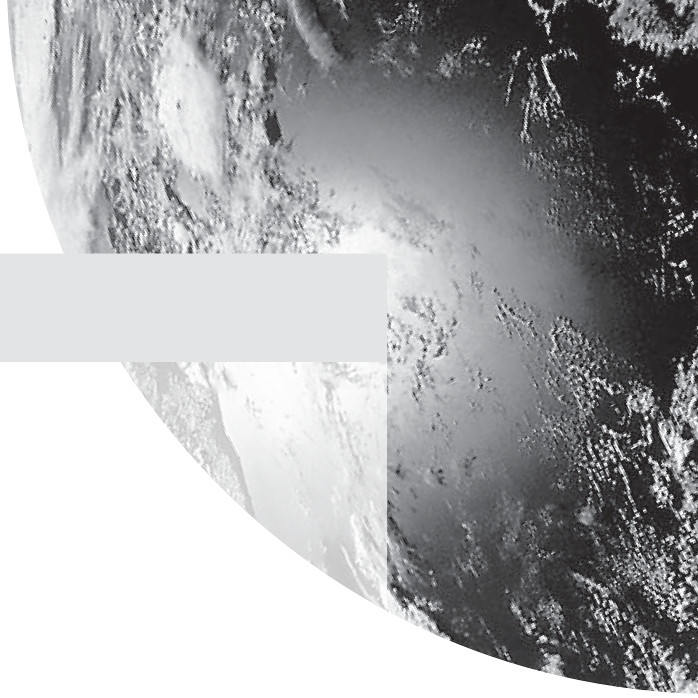

Republic of Korea

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Introduction

Overview of Education System

Under the ideal of *hongik-ingan* (universal welfare of mankind) contributing to the overall benefit of humankind, the objectives of Korean education are to assist all people in perfecting their individual character, to develop an ability to achieve an independent life and acquire the qualifications of democratic citizens, and to be able to participate in building a democratic state and promoting the prosperity of all humankind.

Article 28 of the Act on Government Organization[1] stipulates, "The Ministry of Education and Human Resources Development shall oversee and coordinate human resources development policies, and govern matters related to school education, lifelong education and other academic affairs." The Ministry of Education and Human Resources Development, therefore, is responsible for the establishment of a society which promotes open and lifelong education, as well as systematic and efficient coordination in creating a national human resources development system.

With the enactment of the Local Autonomy Law[2] in 1991, educational autonomy at the local level was promoted with the implementation of new modes of operation. Accordingly, educational administration became decentralized, and the Ministry of Education and Human Resources Development delegated much of its budget planning and major administrative decisions to local authorities.[3] Thus, the Metropolitan and Provincial Office of Education offers to community education authorities and schools, within their jurisdiction, a set of operating guidelines for curriculum organization and implementation by school levels. The national curriculum and the regional guidelines afford flexibility to individual schools in accordance with the particular characteristics and objectives of each school.

Korea has a single-track 6-3-3-4 system, 6 years primary, 3 years of both middle and high school, and 4 years of a university education. This is to ensure that every citizen can receive education without discrimination and according to the ability of each student.

The goal of **preprimary education**, ages 3–5, is to provide an appropriate environment for nurturing children and promoting their wholesome development through various enjoyable activities with a diversified content and method of instruction. In 1997, the Educational Reform Council decided to provide free preschool education for an additional year prior to formal education. The establishment of the public preprimary system is underway to assist children from low-income families with kindergarten tuition, allocating funds to improve facilities at kindergartens annexed to primary schools, enlarging assistance for extended programs, and providing support for teaching materials at private kindergartens.

Primary education, grades 1–6 (for ages 6–11), in Korea is free and compulsory and provides the general rudimentary education necessary in life. The enrollment rate at primary schools is high—99.9 percent.

Middle school includes grades 7–9 (for ages 12–14) and also is free. The purpose of middle schools, which has been compulsory since 2002,[4] is to conduct standard secondary education on the basis of primary education. Since 1971, there has been no limitation placed on entrance into middle school, and all who wish to enter middle school have been assigned to the school nearest to their residence.

The Korean national curriculum is revised on a periodic basis to reflect the newly rising demands for education, emerging needs of a changing society, and new frontiers of academic disciplines.[5] Curriculum standards serve as the basis for educational content at each school and for textbook development. The government has undergone seven curriculum revisions to meet national and social needs, as well as to keep up with the changes related to research development. The curriculum in mathematics and in science is currently in the process of being revised. Mathematics is scheduled to be revised beginning with grade 7 in 2009, and science is scheduled to be revised from grade 7 in 2010.

Language and Population

The language of Korea is Korean. Therefore, education is offered in Korean. According to the most recent census in 2005, the country's population was 48.3 million inhabitants.[6]

Emphasis on Mathematics and Science

The Korean national curriculum comprises the national common basic curriculum and the high school selective-centered curriculum.[7] The national common basic curriculum consists of subject-matter areas, optional activities, and extracurricular activities. The subject-matter areas are divided into 10 different areas including mathematics and science.

Mathematics in the national common basic curriculum is organized and implemented as a differentiated curriculum. Ten levels of mathematics courses are offered from grades 1 through 10, and each level is divided into two sublevels that are operated on a semester basis, respectively. Students must complete a level to move onto the next. Those who fail must take special supplementary classes. Each level has six content domains, and these domains have in-depth processes. The more-able and qualified students study in-depth processes. Those who have a difficult time following the content of study can take supplementary classes. Differentiation of the curriculum can be made by the district office of education or at the school level.

Science also is designed for in-depth and supplementary study, offered from grades 6 through 10. An in-depth course is available for those students who have accomplished all the required subjects. Supplementary courses can be operated for those who have shown poor accomplishment, but nothing is offered in the curriculum for these students. Differentiation is not made by the accomplishment level of students, but can be made by the district office of education or at the school level.

In addition, there are classes for gifted students. The purpose of the Education Center for the Gifted is to provide gifted students with opportunities for specialized education. The public education system and the Metropolitan and Provincial Office of Education also offer programs for gifted students in a variety of areas including mathematics and science.[8] As of 2004, there were 451 classes for gifted students offered to 8,200 students nationwide. Additionally, the Education Center for the Gifted, which has 16,500 students, ran 862 classes. Gifted students make up 0.3 percent of the entire student population.[9]

The Mathematics Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Mathematics Through Eighth Grade

The objectives of mathematics education[10] are the following: understand mathematical knowledge and obtain mathematical skills, cultivate the ability to think mathematically in order to investigate diverse phenomena and solve problems mathematically, and cultivate a positive attitude towards mathematics.

The content domains in mathematics are numbers and operations, figures, measurement, probability and statistics, variables and expressions, and patterns and functions. The standards for each grade that students should learn and achieve are described briefly below.

- *Grade 1*: (numbers and operations) learn numbers up to 100, addition and subtraction of simple numbers, and addition and subtraction of two-digit numbers; (figures) learn shapes of solid figures and shapes of plane figures; (measurement) learn comparisons of quantities and reading time; (probability and statistics) classify objects or people by a predetermined criterion and count the numbers in each category; (variables and expressions) learn expressions using problem-solving methods by trying out, drawing, making expressions, etc.; and (patterns and functions) find patterns in a systematic array, make arrays according to one's own rules, and find patterns in the tables of numbers up to 100.
- *Grade 2*: (numbers and operation) learn numbers up to 1,000, addition and subtraction of two-digit numbers, addition and subtraction of three-digit numbers, and multiplication facts; (figures) learn basic plane figures and build solid figures and the transfer of a plane figure; (measurement) learn hours and time, length such as millimeter and kilometer, and express measured value; (probability and statistics) make charts and graphs; (variables and expressions)

find the unknowns, construct expressions, learn problem-solving methods by making a table, working backward, etc.; and (patterns and functions) find patterns in diverse changes, find patterns in number arrays, make arrays of numbers in order, and find various patterns in the multiplication table.

- *Grade 3*: (numbers and operations) learn numbers up to 10,000, addition and subtraction of four-digit numbers, multiplication and division, fractions, unit and proper fractions, and decimals; (figures) learn angles and plane figures, the transfer of a plane figure, and the components of a circle; (measurement) learn time, length such as millimeter and kilometer, and capacity; (probability and statistics) organize data and properties of data including bar graphs and simple pictographs; (variables and expression) learn problem-solving methods by finding patterns, guessing, checking, etc., and problem-solving methods by explaining the process of problems; and (patterns and functions) find and design various patterns according to rules.
- *Grade 4*: (numbers and operations) learn numbers over five digits, the four fundamental arithmetic operations of natural numbers, various fractions, addition and subtraction of fractions with a like denominator, fractions as a ratio or quotient, and addition and subtraction of decimals; (figures) learn angles and various triangles, the sum of inner angles in a triangle and quadrangle, various quadrangles, perpendicular and parallel, and polygons; (measurement) learn angle measurement, weight, approximation, rounding off, rounding up, and rounding down; (probability and statistics) learn the graph of a broken line and how to express data in appropriate graphs; (variables and expression) learn problem-solving methods by simplifying, logical inference, etc., and solve a problem in various ways; and (patterns and functions) express and explain diverse change patterns in numbers, guessing patterns and expressing them in words or letters, and learn about patterns and correspondence.
- *Grade 5*: (numbers and operations) learn divisors and multiples, reduction and reduction to common denominators, decimals and fractions, addition and subtraction of fractions with unlike denominators, multiplication and division of fractions, and multiplication and division of decimals; (figures) learn properties of a rectangular parallelepipeds and cubes, congruence, and symmetry; (measurement) learn the area of plane figures, various units of weight and area, the perimeter of plane figures, and the area of rectangles and square; (probability and statistics) learn about the stem and leaf diagram and the mean; (variables and expression) solve a problem in various ways, learn problem-solving methods by evaluating the propriety of problems, and compare methods of problem solving; and (patterns and function) learn pattern design.
- *Grade 6*: (numbers and operations) learn division of fractions, division of decimals, and mix calculations of fractions and decimals; (figures) learn properties of prisms and pyramids, properties of cylinders and cones, and various solid figures; (measurement) learn estimation of numbers (greater than or equal to, less than or equal to, and greater or less than), the ratio of the

circumference of a circle to its diameter π(pi), the surface area and volume, and the surface area and volume of rectangular parallelepipeds and cylinders; (probability and statistics) learn ratio graphs including band and circle graphs, and numbers of cases and probability; (variables and expressions) compare the methods of problem solving and learn problem-solving methods by evaluating the propriety of the process of problem; and (patterns and function) learn ratio and rate between two quantities, proportional expressions, continued ratios, and proportional distribution.

- *Grade 7*: (numbers and operations) learn sets, prime factorization, the greatest common divisors, the least common multiples, the decimal and binary systems, the concept of integers and their order relation, the concept and order relation of rational numbers, the four fundamental rules of arithmetic, figures, points, lines, planes, angles, the positional relation of points and straight lines and planes, the properties of parallel lines, simple construction with a ruler and compass, the determination conditions and congruence conditions of a triangle, relation between the central angle and the arc, properties of a polyhedron, a solid of revolution; (measurement) learn the properties of polygons, interior and exterior angles, the area of a sector and the length of an arc, and the surface area and volume of a solid figure; (probability and statistics) learn the frequency tables, histograms, frequency distribution polygons, the mean in the frequency table, and the distribution of relative and cumulative frequencies; (variables and expressions) learn the use of variables, values of expressions, addition and subtraction of linear expressions, linear equations, and properties of equalities; and (patterns and functions) learn direct and inverse proportions, the concept of functions and ordered pairs and coordinates, and graphs of functions and the application of functions.
- *Grade 8*: (numbers and operations) learn the definition of recurring decimals and the relationship between rational numbers and recurring decimals; (figures) learn the proof of the properties of triangles and rectangles, similarities of figures, the properties of similar figures, conditions of similarities of triangles, the ratio of the lengths between parallel lines, the theorem of the midpoint connection of a triangle, and the area and volume of similar figures; (measurement) learn approximate value and error and the range of true values; (probability and statistics) learn the concept and basic properties of probabilities and calculation of simple probabilities; (variables and expressions) learn addition and subtraction of quadratic expressions, the laws of exponents, division of polynomials, deformation of equalities, linear equations with two unknowns, simultaneous linear equations, solutions and basic properties of inequalities, linear inequalities, and simultaneous linear inequalities; and (patterns and functions) learn the meaning and the graph of a linear function, the relation between a linear function and a linear equation with two unknowns and understand the solution of simultaneous linear equalities by their graphs and the application of linear functions.

The Science Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Science Through Eighth Grade

Korea has a national curriculum that covers science instruction[11] from grades 3 to 10. The ministry's guidelines for science can be understood in terms of the following issues: science is a subject that teaches basic scientific knowledge and inquiry process skills and increases the scientific attitude for promoting scientific literacy. Inquiry process skills include observation, measurement, classification, prediction, inference, recognition of problems, formulation of hypotheses, manipulation of variables, data transformation, data interpretation, conclusions, and generalization. The scientific attitude of students will be improved as they learn about environmental problems and real-life problems as material for learning and solving problems through inquiry.

Basic scientific knowledge encompasses concepts associated with energy, material, life, and the Earth. For energy processes, the concepts include energy, electricity and magnetism, force, and light and sound. Material processes include properties of matter, physical states and changes in material, and the classification of material. Life processes include vital life processes, ecosystems, classification of living organisms, and the structure and function of organisms. Earth processes include the Earth in the solar system, Earth's structure and physical features, Earth's history, the circulation of water, and weather. Within this framework, standards for each grade are established. These standards are briefly described below.

- *Grade 3*: (energy) learn about magnets, making a sound, a shadow play, and the measurement of temperature; (material) learn physical states in matter, properties of solids, classification of solid mixtures, and the dissolution of powder in water; (life) learn about the life cycle of a drosophila, breeding an organism in the fishbowl, and observing leaves and stem; (Earth) learn about stone and soil, carried soil, the rounded Earth and moon, and weather.
- *Grade 4*: (energy) learn weighing with two arms balanced, weighing with a spring balance, the transfer of heat, and lighting an electric bulb; (material) learn the properties of liquid matter, the classification of mixtures, temperature and volume, change of matter by heat, and physical state change in water; (life) learn about growing a kidney bean, observing roots, and the structure and function and life processes in animals; and (Earth) learn about searching a constellation, the river and the sea, a geological stratum, and fossils.
- *Grade 5*: (energy) learn about the speed of an object, the image reflected in a mirror and a lens, and framing an electric circuit; (material) learn about making a solution, making a crystal, properties of a solution, and change of a solution; (life) learn about the flower and fruit, the role of a leaf, and observing a small organism, and the environment and organisms; and (Earth) learn about weather changes, the circulation of water, volcanoes and rock, and the family of the sun.
- *Grade 6*: (energy) learn about weight and pressure in water, convenient instruments, and the electromagnet; (material) learn about properties of gas, various gas, and observing candlelight; (life) learn about structure and function

in the human body, characteristics and classification of animals and plants, and ecosystems and environmental pollution; and (Earth) learn about changes of the season, the weather forecast, and earthquakes.

- *Grade 7*: (energy) learn about reflection, refraction, composition, resolution of light, various forces, a resultant force, and the properties of a wave and sound; (material) learn three states of materials, the motion of a molecule, and be able to state change related to energy; (life) learn about cells and the organization of an organism, and the digesting, circulating, breathing, and excreting processes; and (Earth) learn about the structure of Earth, materials of the crust, and the component and movement of seawater.
- *Grade 8*: (energy) learn about the motion of objects and about current and voltage in electricity; (material) learn about the properties of material and the classification of mixtures; (life) learn about the structure and function of plants and stimulation and reaction; and (Earth) learn about the Earth and the stars and the history of Earth and diastrophism.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Time

In principle, an instructional hour is 40 minutes for primary school, 45 minutes for middle school, and 50 minutes for high school. The minimum numbers of total annual instructional hours of mathematics and science by grade during the 34 school weeks of a year include the following.

- *Mathematics*: in grade 1, 120 hours, and in grades 2–8, 136 hours per grade yearly
- *Science*: in grades 3–8, 102 hours per grade yearly (there is no science instruction in grades 1–2).

Instructional Materials, Equipment, and Laboratories

Textbooks and teachers' manuals are developed within the framework of the national curriculum. The textbooks compiled within the framework of the curriculum are classified into three types. The copyright of type one is held by the Ministry of Education and Human Resources Development. Type two textbooks are approved by the Ministry of Education and Human Resources Development and published by private publishers. Type three textbooks are recognized as relevant and useful resources by the Ministry of Education and Resources Development. Primary schools use type one textbooks, while middle schools use type two.

In mathematics, students in grades 1 to 6 receive specifically developed or recommended instructional activity materials separate from the textbook. In science by 2007, each school had at least one modernized laboratory. Since 2005, about 4,450 modernized laboratories have been built. As a result, the project has made a contribution to the improvement of science education.

Grade at Which Specialist Teachers for Mathematics and Science Are Introduced

In the Korean education system, the majority of secondary schools have subject area specialist teachers for mathematics and science, beginning in the seventh grade.

Use of Technology

In mathematics, the use of a calculator is recommended not only to perform complicated calculations but also to help students understand mathematical concepts, principles or laws, and to solve mathematical problems. However, calculators should not be used for teaching and learning about developing calculation skills. In science, adequate use of computer communications networks and multimedia is clearly stated as an objective in the curriculum. Moreover, 10–20 percent of information and communication technology in-class practice is required.

Teachers and Teacher Education

Education and Training for Fourth and Eighth Grade Mathematics and Science Teachers

The classification and qualifications of teachers[12] are defined in Section 2 of Article 21 of the Act on Primary and Secondary School Education.[13] Teachers are required to meet the specific qualification criteria for each category and be licensed by the Deputy Prime Minister and the Ministry of Education and Human Resources Development, as regulated by Presidential Decree.

Teacher education is provided by universities of education, colleges of education, departments of education, and those with teacher's certificate programs in general colleges and universities. Kindergarten teachers are trained at colleges, junior colleges (2-year programs), and the Korea National Open University. Most primary school teachers are trained for 4 years by national education universities. Secondary school teachers generally are trained for 4 years under a mixed system of exclusive and open training systems at teachers colleges, the National University of Education, universities that have education majors, teacher training courses at universities, and graduate schools of education. To be a middle or lower secondary education teacher, a degree from a teacher education program, a prepracticum during a teacher education program, and a supervised practicum in the field for at least 4 weeks are required.

Teacher Professional Development in Mathematics, Science, and Technology

In order to improve the quality and professionalism of teachers, Korea is providing training programs through education offices and universities. Recently, distance training programs also are expanding. Teacher training programs offer qualification training to acquire a higher qualification or performance training to strengthen capacity and are provided at educational training centers under the city or provincial education offices, university-affiliated education training centers, and private training centers. The method of delivering programs includes in class, distance training, and learning at home.

Examinations and Assessments

National or Regional Examinations

To ensure quality control over the national curriculum, the National Assessment of Education Achievement, a student scholastic achievement test, is conducted annually on the national level. The goal[14] is to assess educational progress and achievement, monitor the quality of education at a national level and the appropriateness of the national curriculum, collect background information affecting educational achievement, and provide information on achievement levels to students, teachers, parents, and the government. The subject areas of this assessment are Korean, social studies, mathematics, science, and English. Three percent of students from grades 6, 9, and 10 are sampled. The results of this assessment are documented in a national level report, and information is provided on the student level. However, the results do not influence the grades students receive in school. The Metropolitan and Provincial Office of Education also conducts examinations of student achievement.

Other Tests

In order to be admitted to a university after completing grade 12, students must take the College Scholastic Ability Test. The Metropolitan and Provincial Office of Education also operates some entrance tests for high school admission.

Monitoring Individual Student Progress

Schools conduct evaluations of the attainment level of students by grade and level of the subject area, by using various assessment tools and methods. In principle, the elementary school shall report the evaluation record of individual students in the form of written documents, in terms of the student's activities, personal traits, and progress in their subject matter.

Middle school students are evaluated at the end of each academic semester. The results are included on the student's school transcript by each subject teacher, which also includes the student's rank, as well as the total number of students enrolled in the subject course. The number of students who are placed in the same rank also is indicated. The level of a student's academic performance on tests is evaluated and given in grade letters according to the percentage group the student falls into: 90 percent or higher (A), 80–89 percent (B), 70–79 percent (C), 60–69 percent (D), and less than 60 percent (E). This information also is included in the transcript.

Grade Promotion and Retention Policies

If students have completed a grade, they move onto the next grade automatically. However, in mathematics and English, students need to complete a level to move onto the next grade. Those who fail to complete a level must take special supplementary classes.

Suggested Readings

http://english.moe.go.kr

http://www.kice.re.kr/kice/eng/index.jsp

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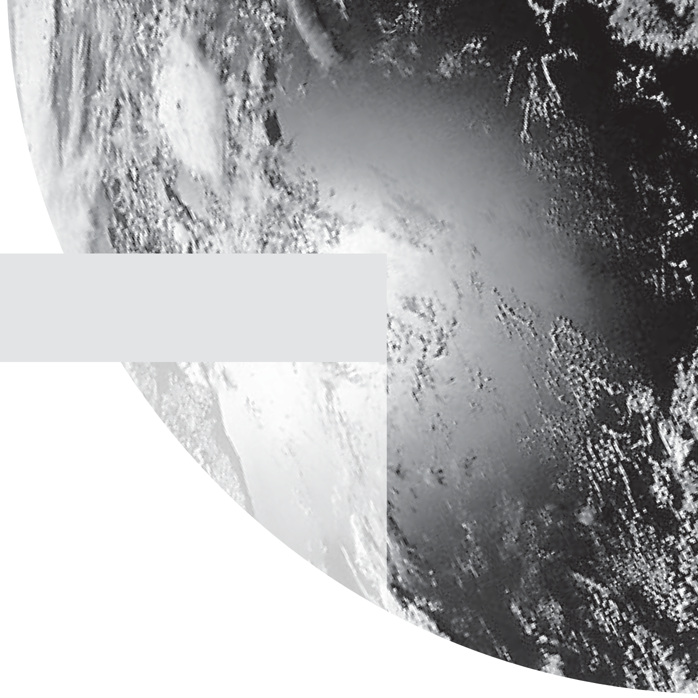


Kuwait

Ebraheem Al-Qattan
Ministry of Education

Introduction

Overview of Education System

Kuwait's education system consists of 5 years of primary education (ages 6–10), 4 years of intermediate education (ages 11–14), and 3 years of secondary education (ages 15–17).[1] In Kuwait, school is compulsory for children ages 6–14.

The government also supports 2 years of kindergarten (ages 4–5), where the pedagogical emphasis is on enjoyable play activities and the development of basic linguistic and cognitive skills, as well as self-confidence and creativity. Preprimary education fulfills a social function only, since it is not compulsory.

The Ministry of Education is responsible for administration of the public school system, including enforcing general rules and regulations, developing curriculum and pedagogical methods, and recruiting national and non-national teachers. While the education system is centralized, six district level offices have responsibility for teacher assignment, assessments that contribute to the final secondary school public examination mark, and local administration. Private schools are attended by Kuwaiti and non-Kuwaiti children and must be accredited by the Private Education Administration of the Ministry of Education, which monitors staff qualifications and school conditions.

In the 2005–2006 school year, there were 1,145 schools in Kuwait, of which 664 were public and 481 were private. There also are schools for special needs students. A limited number of religious schools cater to males, from the intermediate school level through the secondary stage. In private schools, Kuwaiti students accounted for approximately 12 percent of primary school enrollment, 9 percent of intermediate, and 9 percent of secondary school enrollment. Despite the fact that non-Kuwaitis represent the majority of the population, approximately 60 percent of the school-age population is Kuwaiti. This is a reflection of the fact that the children of many non-Kuwaitis reside in their home countries.

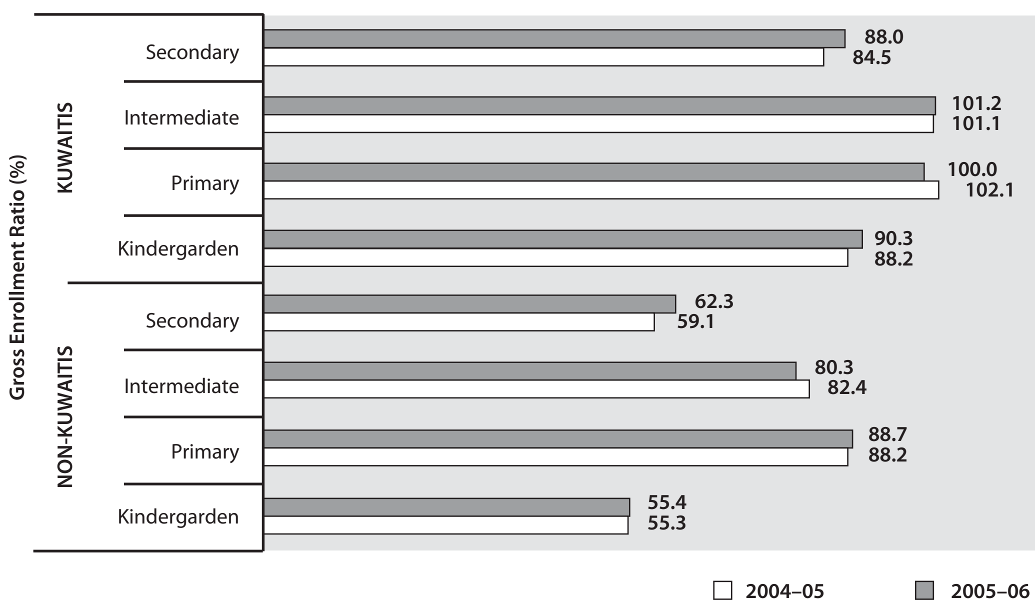
Students attending Kuwait public schools and private Arabic schools follow a common national curriculum. At the secondary level, public school students have a choice of academic or credit hour systems. Students in foreign private schools have curricula and courses similar to those offered in the affiliated countries. However, private schools also are required to include aspects of the Kuwaiti culture and language in the curriculum. At primary, intermediate, and secondary education stages, tracking or streaming within schools is not permitted.

Public education is provided free for Kuwaitis and some non-Kuwaiti children (e.g., children of teachers or professors, Kuwaiti mothers, or Gulf state nationals). While overall expenditure per pupil is similar to the Organisation for Economic Co-operation and Development (OECD) norm, a closer analysis of the figures shows an imbalance in per pupil expenditure in favor of tertiary and vocational students, as well as kindergarten students over primary, intermediate, and secondary students. Students attending private schools, including Arabic and foreign schools, schools for children with special needs, and private universities are required to pay fees. Private Arabic schools receive some government support, including assistance with site costs and textbooks.

Recent education reforms include the replacement of a two-tiered secondary system with a unified system. Also, under the new system, students accumulate final examination marks based on their performance in grades 10 (5%), 11 (35%), and 12 (60%), instead of on a single summative examination.

The gross enrollment ratio (i.e., the number of students at any age enrolled in any grade of an educational level expressed as a percentage of the age group intended for that level) for each of the kindergarten, primary, intermediate, and secondary levels is presented in Exhibit 1. It shows much higher participation rates for Kuwaitis than for non-Kuwaitis at all levels, but most noticeably at the kindergarten level.

Exhibit 1 Gross Enrollment Ratios by Level and Citizenship, 2004–2005 and 2005–2006 School Years



Source: Ministry of Education. (2008). *Kuwait education indicators report, figure c4* (p. 42). Kuwait City, Kuwait: Author

Student-teacher ratios (based on the number of students at an educational level divided by the number of staff at that level) are low. According to the *Kuwait Education Indicators and Assessment Project 2008* report,[2] in the 2005–2006 school year, the student-teacher ratios were 8.2 at the primary level, 9.5 at the intermediate level, and 6.6 and 6.9 at the secondary academic and credit levels, respectively. Figures for average class size present a different picture. The averages for primary, intermediate, and secondary school are 24.6, 29.7, and 24.3, respectively.

Language and Population

Standard Arabic is the official language used for printed matter, as well as for official and formal purposes and occasions. The Kuwaiti dialect, which is a variety of Arabic, is often used instead of standard Arabic for everyday communication. The language of instruction during the general education stages (K–12) is Arabic. English also is used as the language of instruction for mathematics and science in some private schools.

Kuwait has a population of approximately 3 million, of which one third are non-Kuwaitis. Non-Kuwaitis are mainly from Bangladesh, Egypt, India, Pakistan, the Philippines, and Sri Lanka. The vast majority of the population resides around Kuwait City. The school-age population (ages 4–21) includes approximately 426,000 Kuwaiti and approximately 290,000 non-Kuwaiti students.

Emphasis on Mathematics and Science

General support for mathematics and science comes from the Ministry of Education. Some support for specific activities related to mathematics and science at the secondary level also has been received from the Kuwait Foundation for the Advancement of Sciences, including support for international mathematics competitions. The ministry provides a grant to support remedial teaching in mathematics and science (and in other subjects). The grant program, to which parents also contribute, is used to pay tutors. The ministry fosters interest in science through its support of science clubs.

The Mathematics Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Mathematics Through Eighth Grade

The general supervisors of mathematics and of science are responsible for making curricular decisions, in consultation with the curriculum sector of the Ministry of Education. Currently, the mathematics curriculum is being revised. The mathematics content for primary and intermediate education is described below.

By the end of **grade 4**, students are expected to have covered the following aspects of the mathematics curriculum: recognizing and counting numbers up to 9,999,999; simple addition, subtraction, multiplication, and division; fraction concepts; measurement, including units of length; perimeter and area; basic geometric concepts; and units of time.

By the end of **grade 8**, students should have covered rational numbers; algebraic expressions; mathematical sentences; basics of statistics; geometry, including reflection and congruency; factors and multiples; fractions; decimals and percentages; geometry of a circle and a square; ratio and proportion; measurement related to length; volume and area; and problem solving or application of these curricular topics.

The Science Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Science Through Eighth Grade

Before the **end of grade 4**, the curriculum focuses on life sciences and the environment, natural sciences, and earth and space sciences. Life sciences and the environment includes personal hygiene, social interaction, and basic facts about animals, insects, plants, animal breeding, animal habitats, the human body, and the role of the sea. Natural sciences covers light, sound, temperature, fire, magnetism, water, air, pollution, electricity, and transportation. Earth and space sciences introduce students to the sun, moon, seasons, rain, Earth's gravity, and themes related to oil, including sources, exploration, and benefits.

By the **end of grade 8**, students should have studied some of the topics covered in primary and earlier intermediate grades in greater depth. The curriculum is divided into three sections: life sciences, natural sciences, and earth sciences and astronomy. The life sciences focus on parts of the plant, photosynthesis, aquatic plants, environmental pollution, simple organisms, the relationship between man and microbes, infectious disease and treatment, viruses, air and gases, tissue components, and HIV/AIDS, including protection against the disease. The natural sciences include elements and compounds, mixtures and solutions, features of materials, temperature, power and energy, magnetism, sound, acids, the atom, electricity, light, mass, and measurement. Topics covered under earth science and astronomy include the Earth, the moon, the stars, and the sun; the solar system; man and the universe; air pressure; seasons; and man and weather.

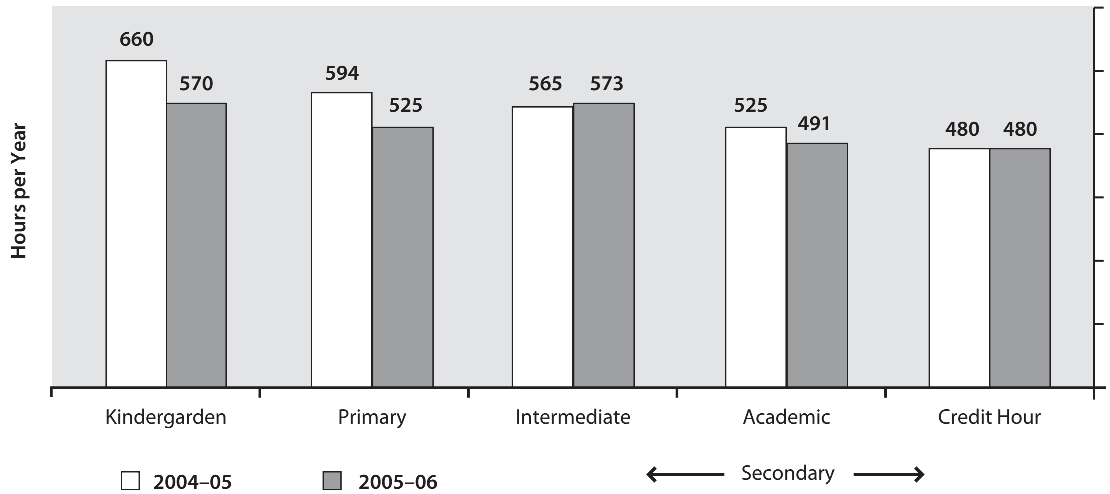
Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Time

By international standards, the academic year in Kuwait is short and the number of instructional hours is low. The academic year is 33 weeks for primary school and 32 weeks for intermediate and secondary levels. While there was an increase in the number of hours per year that primary students are expected to be in school (up 33 hours to 858 hours per year), this is still much lower than other countries, and about 50 hours per year less than the average for the OECD countries. Students are expected to receive 800 hours of instruction annually during intermediate and secondary school.

Exhibit 2 presents details of statutory teaching hours for teachers in public schools. In 2005, the average teaching time was reduced for kindergarten by 90 hours, for primary by 69 hours, and for secondary academic education by 34 hours. While statutory teaching hours are low compared to other countries, the average actual teaching time is even less than this, particularly in intermediate schools, where average actual teaching time has been reported to be 240 hours less than the requirement. In comparison with their public school counterparts, private school teachers have considerably more teaching hours—70 percent more at the intermediate level and 50 percent more at the secondary level.

Exhibit 2 Average Statutory Teaching Hours per Year in Public Schools in the 2004–2005 and 2005–2006 School Years



Source: Ministry of Education. (2006). *Summary report for the assessment project (Kuwait Education Indicators and Assessment Project) figure c 42* (p. 69). Kuwait City, Kuwait: Author

At the primary level, class periods are 40 minutes. Mathematics should be taught each school day and science should be taught three times a week. Class periods at the secondary level are 45 minutes. Students in grade 8 also are expected to study mathematics each school day and science three times per week. The actual number of class periods offered over the school year tends to be considerably lower because of holidays.

Instructional Materials, Equipment, and Laboratories

The Ministry of Education provides free textbooks to all public school students. Instructional materials and equipment used for mathematics and science include textbooks, teacher guides, teaching aids, computers, calculators, etc. There also are laboratories.

Grade at Which Specialist Teachers for Mathematics and Science Are Introduced

Students first have specialized teachers for mathematics and science in grade 1 of primary school.

Use of Technology

A variety of technology is used in instruction and for distance learning, including computers and calculators.

Teachers and Teacher Education

Education and Training for Fourth and Eighth Grade Mathematics and Science Teachers

A teacher must have a university degree to be formally recognized. Four-year preservice teacher training programs are offered by Kuwait University, the College of Basic Education, which is affiliated with the Public Authority for Applied Education and Training, and the Open University. There is some concern that the standard to become a mathematics teacher is relatively low. Irrespective of their majors, students within each college are expected to take common courses in education and psychology, as well as practicals. Teaching of mathematics and science is covered in teaching methods courses. Teacher preparation includes teaching practice. At the end of their course of study, prospective teachers have a 1-year practicum and are evaluated by school supervisors, as well as by staff from their preservice training institutions.

Teacher Professional Development in Mathematics, Science, and Technology

Practicing teachers are expected to update their content knowledge and pedagogical skills through attendance at professional development programs. These are offered by the Ministry of Education's Training and Development Department in a specialized training center. Training is offered by ministry officials and academic staff from institutions who also offer preservice training. Mainly, courses focus on improving teaching skills, including those of mathematics and science teachers. Some teachers also can be nominated to participate in training programs outside of Kuwait.

Examinations and Assessments

National or Regional Examinations

There are no formal national or regional examinations at the primary level. At both the intermediate and secondary levels, schools set examinations in a range of subjects, including both mathematics and science.

The High School Examination remains the single most important assessment in the life of a student. This high-stakes examination certifies that the student has satisfactorily completed the secondary school program, and it also serves as a selection mechanism for further education and for jobs. In 2006, girls performed better than boys as a group in all subjects. Students who fail the High School Examination may take the examination at the beginning of the following academic year or may repeat grade 12.

Other Tests

Standardized testing is not a feature of the education system in Kuwait. Students have, however, participated in three large-scale studies that have used standardized tests: the Progress in International Reading Literacy Study (PIRLS), which assessed reading literacy at grade 4 in 2001 and 2006; the National Assessment of Learning Outcomes, which assessed achievement in grades 4 and 8 in Arabic, English, Islamic studies, mathematics, and science; and TIMSS. The PIRLS 2006[3] findings revealed, among other things, that students in Kuwait were more likely than students in other countries to skip questions. The first Kuwait National Assessment of Learning[4] found overall low achievement in mathematics, especially in one district (*Al-Jahra*). It also indicated a high level of teacher dissatisfaction with their occupation and poor relations between teachers and parents.

Monitoring Individual Student Progress

Subject teachers are expected to carry out both oral and written continuous assessment throughout the year. This requirement has contributed to teacher dissatisfaction with the amount of time spent testing and recording results. It also has been a subject of criticism from parents.

Grade Promotion and Retention

Students are required to pass examinations at intermediate and secondary levels to gain promotion to the next highest grade.

Grade repetition is permitted and has become an issue especially at the secondary level. Repetition rates tend to be highest at the secondary level (17% for boys and 12% for girls). The next highest is at the intermediate level (8% for boys and 5% for girls), and it is lowest at the primary level (2% for boys and 1% for girls). Grade repetition has contributed to the large percentage of over-age secondary school students—around 30 percent are older than the expected age.

Suggested Readings

http://www.kuwait-info.com/sidepages/edu_minedu.asp

http://www.kuwait-info.com/sidepages/edu_over.asp

http://www.moe.edu.kw/

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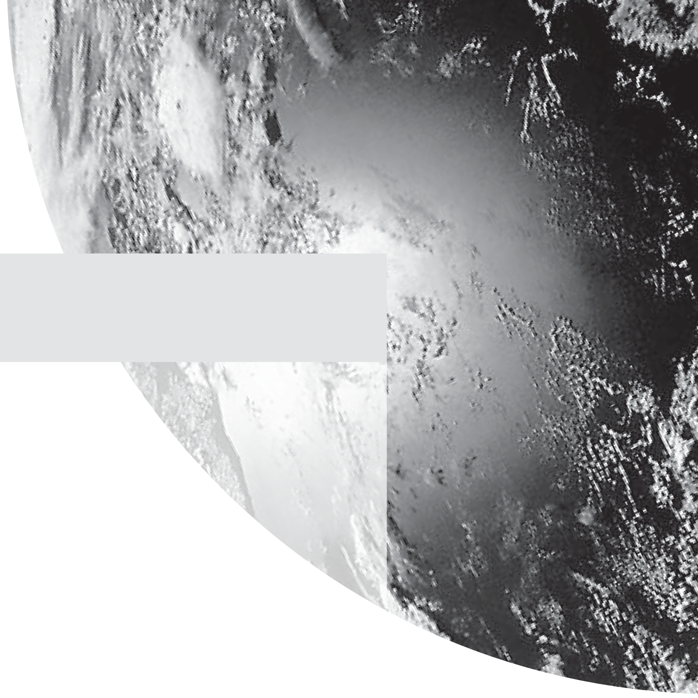

Latvia

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Introduction

Overview of Education System

The education system in Latvia is administered at three levels—national, municipal, and institutional. The Latvian Parliament (*Saeima*), the Cabinet of Ministers, and the Ministry of Education and Science are the main decision-making bodies at the national level. The Ministry of Education and Science is the education policy-making institution. It issues licenses for new comprehensive education institutions and sets education standards along with the content and procedures for teacher training.

The following laws and regulations are the basis of the education policy in Latvia.[1]

- Law on Education (1998) contains the definitions of all types and levels of education and sets the general principles and competencies of the governing bodies
- Law on General Education (1999) stipulates in detail the main organizational principles and procedures of general education services
- Law on Professional Education (1999)
- Law on Higher Education Establishments (1995).

In addition, education policy is shaped by regulations and standards issued by the Latvian Cabinet of Ministers, and decrees, instruction, and methodology guidelines are issued by the Ministry of Education and Science.

The major levels of education are preprimary education, including compulsory education for children ages 5 and 6; compulsory general basic education (grades 1–9); general secondary education (grades 10–12); and tertiary education.

Preprimary education focuses on comprehensive child development, health strengthening, and preparation for basic education.[2] It is meant to encompass a child's mental, physical, and social development up to the age of 7 (children enter the first grade in that calendar year when they turn 7). This is provided in preschool education institutions, special preschool education institutions, and preparatory groups in general education institutions, as well as in families.[3]

According to the Ministry of Education and Science, the primary goal of preschool education is to develop the abilities of each child; stimulate their willingness to learn about the surrounding world; develop their social skills, perceptions, and memory; and prepare them for basic education programs by developing their speech and preparing them for reading and writing.

General basic education (grades 1–9) in Latvia can be acquired in vocational schools, special education institutions, night (part-time) secondary schools, education institutions, or classes for social or pedagogic correction (for students with behavior problems or those requiring academic support).[4] These programs are provided in primary schools and basic schools, depending on the structure of the education institution and how the teaching and learning process is organized.[5]

General secondary education in Latvia is acquired in 3 years (grades 10–12). This level of education can take place in secondary schools, night (part-time) secondary schools, and *Gymnasiums* (intensified general secondary education).[6]

In the 2007–2008 school year, there were 33 private general education schools in Latvia. There also were 46 primary schools, 470 basic education schools, 379 secondary education schools, and 63 special education schools.[7] For general secondary education, from 2005 to 2008, extra funding for mathematics and science subjects was available within the framework of the European Union's structural funds program governed by the Centre for Curriculum Development and Examinations under the Ministry of Education and Science.

Language and Population

Latvian is the official language of Latvia and the primary language of instruction, although there are schools that provide instruction in eight other minority languages. In the 2007–2008 school year, Latvian was the language of instruction in 722 schools, Russian was used in 141 schools, and 88 schools had both Latvian- and Russian-speaking classes. A small number of schools also provide all or some instruction in Polish, Ukrainian, Byelorussian, and English.[8]

In 2007, Latvia's population was 59 percent Latvian, 28.3 percent Russian, 3.7 percent Byelorussian, 2.5 percent Ukrainian, and 2.4 percent Polish. In total, 4.1 percent of the population is Lithuanian, Israeli, Gipsy, German, or Estonian.[9]

Overarching Policies Related to Education and the Curriculum for Mathematics and Science

The basic education (grades 1–9) standard of Latvia determines the main aims and tasks, the mandatory content, the main criteria, and the arrangement for the evaluation of student achievement in basic education. There is one standard for everybody except students with mental disorders. Subject standards, part of the basic education standard, determine the main aims and tasks of each subject, the mandatory content of the subject, and the forms and order of the evaluation of achievement. The first version of the current primary education standard of Latvia was developed and approved in 1998. Recent changes and developments are reflected in the Regulations Number 1027 of the Cabinet of Ministers of Latvia, "About state standard of primary education and subject standards of primary education" (December 19, 2006).[10] In 2007 and 2008, changes were enacted to these regulations.

The compulsory content of the basic education should cover the following domains.

- Technology and the basics of science (mathematics, informatics, science, physics, chemistry, biology, and geography)
- Language
- The arts
- People and society.

The Mathematics Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Mathematics Through Eighth Grade

The mathematics standards for Latvia in primary grades contain the following five parts.

- Objective and tasks of the subject
- Mandatory content of the subject
- Basic requirements for mastering the academic subject upon graduating from the third grade
- Basic requirements for mastering an academic subject upon graduating from the sixth grade
- Basic requirements for mastering an academic subject upon graduating from the ninth grade.

The first part (objective and tasks of the subject) is common for all standards. The second part (mandatory contents of the subject) includes all content topics that students should learn in mathematics during basic school (see below). The last three parts include requirements for graduating from grades 3, 6, and 9, respectively.

The objective of mathematics is to help students understand mathematical methods and develop their skills to learn about the world, other academic subjects, and multiform activities. The tasks of mathematics create an opportunity for students to achieve the following.

- Master the skills to deal with real numbers, using correlations and analytical methods; study the geometrical figures of planes and the properties thereof; and develop dimensional perceptions.
- Master the skills to research and solve practical tasks by using mathematical models and obtaining, arranging, analyzing data, and forecasting the expected result.
- Promote the development of thinking by forming the ability to express mathematically grounded decisions and improving problem-solving experience.

The mandatory contents of the subject and their related subtopics include the following.

- **Formation of mathematical sets of instruments**. *Number and computations*: natural numbers, regular fractions, decimal numbers, rational numbers, and real numbers; *algebraic expressions and computations*: algebraic expressions, equations with a single variable and systems, single variable inequalities and systems, single argument functions, and strings of numbers; *geometric shapes and their study*: basic geometric elements, triangles, quadrangles, circumference and circle, polygons with varied number of sides, regular polygons, symmetry of planar shapes, and geometric figures.
- **Use of mathematics in the analysis of natural and social processes**. *Measurements and their metering, including correlation*; *elements of information processing, statistics, and the theory of probability:* collecting, processing, and analyzing information and groups of elements, as well as the concept of probability.
- **Formation of mathematical models and the study of methods characteristic of mathematics**. *Mathematical language*; *formation and analysis of mathematical models*: specification of a problem, formulating it mathematically, using a mathematical model, solving a mathematical model, and interpreting the solution.

Each teacher can use the mathematics standards to make his or her own program for each grade or use an example program that is approved by The Center for Curriculum Development and Examinations. This program and sets of books (student textbooks, workbooks, and the teacher book), approved by the center, are additional information for teachers.

There are some challenges to implementing the mathematics standards in Latvian schools due to the organization of the grades. Usually, the basic school organization is in two levels: grades 1–4 and grades 5–9. In grades 1–4, there is one teacher in all subjects (with the exception of music, sports, etc.). In grades 5–9, usually there are subject teachers. There also are beginners' schools with only grades 1–4 (more likely in rural areas closer to students' homes).

The Science Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Science Through Eighth Grade

The science standards of Latvia contains the following four parts.

- Objective and tasks of the subject
- Mandatory content of the subject
- Basic requirements for mastering the academic subject upon graduating from the third grade

- Basic requirements for mastering an academic subject upon graduating from the sixth grade.

Parts 3 and 4 of the science standards contain detailed information about basic requirements for mastering the academic subject upon graduating from the third and sixth grades, respectively. There are more than 100 requirement items in each of these parts of the standards.

The goal of the science curriculum is to create an opportunity for the student to accomplish the following.

- Learn the basics of research work in science
- Study nature's systems and processes by learning to understand the diversity and unity of nature
- Understand the importance of achievements in the natural sciences in the daily lives of humans and understand the necessity of preserving the environment and health by obtaining practical experience in preserving and improving the quality of the environment.

In the science standards, the following themes are used as the basis for structuring subject content.

- Basics of research work
- Nature's systems and processes
- Interaction between humans and the environment
- Basics of research activities

The science standards in Latvia are not structured by year. The sequence of particular topics can be found in the subject syllabus. Taking into account the fact that this syllabus is only a guide, teachers have the opportunity to develop their own syllabi, taking into account the general requirements of the science standards and the general purposes of primary education.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Time

Regulations Number 1027 of the Cabinet of Ministers of Latvia, "About state standard of primary education and subject standards of primary education" define the following time schedule for the number of lessons per grade per week in technology and fundamentals of sciences for grades 1 to 6 and in the different science subjects (biology, physics, chemistry, and geography) for grades 7 to 9 (see Exhibit 1).

Exhibit 1 Instructional Time (Number of Lessons per Week) in the Sciences in Basic Education in Latvia

Content Areas and Subjects (Excerpt)	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Grade 9
Technology and Fundamentals of Sciences									
Science	2	2	2	2	2	2			
Biology							2	2	2
Physics								2	2
Chemistry								2	2
Geography							2	2	2

The number of lessons per subject per week is mandatory. The length of the school day for children, ages 5–7, may not exceed 120 minutes.[11] Content coverage is not mandatory, but different subject syllabi are available for all teachers who are not able or do not want to develop their own syllabus. In science, beginning in grade 7, the different subjects (biology, physics, chemistry, and geography) have their own subject standards.

For mathematics, the number of lessons per grade per week is four in grades 1 to 4, five in grades 4 to 6, six in grade 7, and five in grades 8 and 9.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

As mentioned above, in grades 1–4, there is one teacher for all subjects (with the exception of music, sports, etc.). In grades 5–9, usually there are subject teachers.

Teachers and Teacher Education

Education and Training for Fourth and Eighth Grade Mathematics and Science Teachers

To ensure the highest quality in education, specific requirements have been stipulated by the state for teacher training and qualifications.[12] Since 2004, a teacher must have a higher education degree and relevant qualifications, in compliance with the procedure set by the Ministry of Education and Science. Thirty-six hours of professional development are required in a 3-year period. Nine state higher education institutions provide full-time professional teacher training programs.

A teacher's first degree in education is a bachelor's degree (3–4 years), and his or her second degree is a master's degree (1–2 years). A bachelor's degree in a scientific discipline corresponding to the subject is allowed if a teacher starts his or her studies in a teacher education program during the 2 years after beginning employment. Designed for teachers who already have a bachelor's degree in education, a teacher qualification for an additional subject area can be acquired in 1–2 years. Qualification for preprimary teachers, household teachers at the general basic and secondary level, hobby education teachers, librarians, and sport instructors can be acquired in 2–3 years.

Examinations and Assessments

National or Regional Examinations

The examination system in Latvia was established in order to assess the scope, quality, and level of the acquired learning content; the acquisition of supplementary information;

initiative; independent learning; cooperation and communication skills; and the dynamics of learning and achievement. The system also is intended to encourage the development of positive attitudes toward learning, oneself, and the surrounding community, as well as the development of accuracy, diligence, goal directness, self-control, and motivation. The examination system, introduced in 1992, consists of a single assessment at each grade level based on a 10 point scale (10 being the highest mark), as well as a descriptive assessment.

- In grade 1, a brief, evaluative written or oral description of the student's learning activities, style of work, communication and cooperation skills, attitudes, and development is provided.
- In grades 2 and 3, a 10-point scale is used in the Latvian language, mathematics, and the ethnic minority language. In other subject areas, the evaluation is descriptive.
- In grade 4, a 10-point scale is used in the Latvian language, mathematics, natural sciences, and the ethnic minority language. In other subject areas, the evaluation is descriptive.
- In grades 5–9, a 10-point scale is used in all core subject areas. In special subjects (e.g., ethics, health education), students are designated as "complete" or "incomplete."

The purpose of introducing this system was to attain international recognition of the education provided in Latvia, compare student achievement in the courses of study, and organize student assessment at the school level.

Tests at the end of grades 3 and 6 and centralized examinations at the end of the general basic education level (grade 9) are organized on the national level. The content and procedure for 13 national tests, 3 examinations, 1 centralized examination, and 1–2 diagnostic tests are devised nationally at the level of general basic education.

- In grade 3, a combined cross-curricular test and a test in the Latvian language (for ethnic minorities' education programs) are administered.
- In grade 6, tests are administered in the language of instruction, mathematics, and the Latvian language (for ethnic minorities' education programs).
- In grade 9, tests are administered in a foreign language, natural sciences, and sports. Examinations in the language of instruction, the Latvian language (for ethnic minorities' education programs), mathematics, and history are administered.

Monitoring Individual Student Progress

Student achievement in general basic education is recorded in a school report at each grade at the end of each semester, as well as through a certificate of basic education. After being assessed in all the subjects set by the general basic education program and the administration of state examinations, grade 9 students receive a certificate of general basic education and an achievement sheet.[13]

Suggested Readings

Central Statistical Bureau of Latvia, homepage: http://www.csb.gov.lv

Ministry of Education and Science Republic of Latvia, homepage: http://izm.izm.gov.lv/58.html

The Centre for Curriculum Development and Examinations, homepage: http://isec.gov.lv/en/index.shtml

The Centre for Curriculum Development and Examinations. (n.d.). *Basic educational standards*. Retrieved May 6, 2008, from http://isec.gov.lv/en/standards.shtml

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Lebanon

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Introduction

Overview of Education System

The education system in Lebanon is centralized, with all educational institutes in the public sector regulated by the Ministry of Education and Higher Education in Beirut. However, this regulation is not direct, but is managed through regional education bureaus. The regional education bureaus at the center of each governorate monitor public schools in the governorate 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, on the other hand, have their own organization. In regard to educational decisions, however, these schools are still subject to the authority of the ministry.

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

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

- *Kindergarten*: ages 5–6
- *Basic education*: elementary level (includes cycle 1, grades 1–3, and cycle 2, grades 4–6) and intermediate level (cycle 3, grades 7–9)
- *Secondary education*: cycle 4, grades 10–12.

Schooling in Lebanon is compulsory through grade 6 (i.e., kindergarten plus the 6 years of elementary education). Private schools usually include all the pre-university classes (kindergarten, basic education, and secondary education). As for public schools, there are some that have only basic level grades, others also include kindergartens, and most include secondary level classes.

Public schools are financed by the Ministry of Education, and private schools by student fees. However, the processes involved in drafting and modifying curricula and providing teacher training mainly are financed by nongovernment funds such as private companies or international bodies including the United Nations Development Programme (UNDP) and the World Bank.

The Lebanese curriculum is used at all schools in Lebanon, whether public or private. If some schools wish to implement a foreign curriculum (French, English, or international) in a school, they are obligated to apply both the Lebanese and foreign schemes at the same time.

Since Lebanon joined TIMSS 2003, no modifications or reviews have been made to the mathematics and science curriculum. Presently, however, the curricula for cycles 1 and 2 in basic education are being reviewed by the ECRD. Concerning the revision of the mathematics and the science curriculum for the eighth grade, the TIMSS 2003 and 2007 results will be taken into consideration, among other results.[1]

Language and Population

The teaching of mathematics and science in public and private schools is conducted in Arabic throughout the first and second cycles of basic education and also may be taught in a foreign language (French or English). However, in the third cycle, teaching is conducted in a foreign language (French or English).

The Mathematics Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Mathematics Through Eighth Grade

The curriculum assures that students who finish basic education (elementary level), second cycle, **grades 4–6,** have the necessary skills they need and a solid foundation in mathematics. Thus, students must be able to do the following in the mathematical domains described below.[2]

- *Mathematical reasoning*: find tendencies in a sequence of results and generalize them; extract general statements out of specific contexts; establish procedures; and argue by providing an analogy and giving examples and counter-examples.
- *Problem solve*: visualize situations and handle information; use and apply mathematics in various domains, especially in technology and other branches of learning; verify results; and use minicalculators to carry out the four 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 figures and use geometric instruments to represent them, and develop an understanding of some solid figures.
- *Numerical*: master the Indo-Arabic system of numeration; recognize decimal numbers; master all types of calculation, including computational and mental and learn to use a minicalculator (for integers and decimals); perform simple operations with fractions; and estimate a result.
- *Measurement*: measure perimeters, areas, capacity, 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 the **fourth grade** of basic education, second cycle (elementary level).

Exhibit 1 Mathematics Content in Grade 4 of Basic Education in Lebanon

	Arithmetic and Algebra
Numbers	Natural 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 straight lines and parallel straight lines Classification of quadrilaterals according to its sides Circle and disc
Transformations	Drawing the symmetric of a figure with respect to an axis
	Measurement
Length	Metric units of length
Mass	Metric units of mass
Area	Comparison of areas
Angle	
Capacity	Liter and submultiples
Volume	
	Statistics
Handling Data	Collecting and organizing data

In basic education (intermediate level), cycle 3, **grades 7–9,** students must be able to do the following in the mathematical domains described below.[3]

- *Mathematical reasoning*: find connections between the real world and mathematical models and between these models and concepts, learn the general term of a sequence of results duly constructed, distinguish between a general statement and a particular one, carry out simple proofs, and recognize a false proof.
- *Problem solve*: analyze a situation and deduce the relevant elements; look for necessary information to clarify an incomplete that is given; construct a mathematical model associated with a situation; choose a strategy to find the solution; deconstruct a problem into simpler tasks, and conversely, combine necessary facts to reach a conclusion; and use a calculator with memory.
- *Communication*: read, understand, and use mathematical notations and language and present work orally or in writing, with clarity and rigor, and with particular care when writing a proof.
- *Spatial*: construct geometric figures based on a given, represent solid figures, prove and apply the properties of plane figures, and perform affine transformations on figures.
- *Numerical*: find and use relations among numbers, extend computational techniques to literal expressions, and find approximate values of a result.
- *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 the **eighth grade** of basic education, third cycle (intermediate level).

Exhibit 2 Mathematics Content in Grade 8 of Basic Education in Lebanon

	Arithmetic and Algebra
Numbers	Natural integers Fractions Decimals Square Roots
Operations	Powers of a positive number having a positive integer exponent Powers of a negative integer exponent of 10
Proportionality	Inverse proportionalities
Algebraic Expressions	Remarkable 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

Exhibit 2 Mathematics Content in Grade 8 of Basic Education in Lebanon (Continued)

Solid Geometry	Plane representation of a cylinder, a pyramid, cone, and sphere Relative positions of straight 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: circular diagram and cumulative frequency polygon

The Science Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Science Through Eighth Grade

Science plays an important role in everyday life. 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 the school years.

To achieve this goal, the general objectives of science teaching are the following.[4]

- Develop learners' intellectual and practical scientific skills
- Deepen learners' awareness of the ability of humans to understand, invent, and create
- Understand the nature of science and technology, their development across history, and their impact on human thought
- Ensure that learners 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 learner aware of the role of science in sustaining these resources
- Encourage learners to use scientific knowledge and skills in novel situations, especially in everyday life
- Emphasize the role of scientists in the advancement of human kind
- Encourage learners to be open to the ideas of scientists from different cultures and understand their contributions to the advancement of science
- Encourage learners to abide by scientific values such as honesty and objectivity

- Develop learners' scientific curiosity and orientation toward scientific research
- Encourage learners to work independently and cooperatively in solving scientific problems
- Make learners aware of career possibilities in different science-related areas.

Exhibit 3 presents a summary of the science concepts and skills to be covered in **fourth grade** of basic education (elementary level), second cycle.

Exhibit 3 Science Content in Grade 4 of Basic Education in Lebanon

Subject	
Plants And Their Habitats	Fresh water habitat and plants Classification of plants
Animals and Their Habitats	Fresh water habitat and animals Classification of animals
Man and his Health	Support and movement systems Food pyramid
Man and the Environment	(Included in the other themes)
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 **eighth grade** of basic education, third cycle (intermediate level).

Exhibit 4 Science Content in Grade 8 of Basic Education in Lebanon

	Life and Earth Sciences
Nutrition	
Reproduction and Genetics	Puberty and adolescence Reproductive organs Functioning of the reproductive system Fertilization, development, and birth Birth control Sexually transmitted diseases: AIDS
Immunology	Immunological specificity Deficiency and disorder of the immune system Preventive and curative methods

Exhibit 4 Science Content in Grade 8 of Basic Education in Lebanon (Continued)

Earth and the Environment	Geology: earth science Manifestations of Earth activities Structure and dynamics of the Earth Circulation of matter on Earth Geology and human responsibilities
	Chemistry
Classification and Constituents of Matter	Pure substances: elements; compounds; atoms, molecules, and ions; and symbols and formulas Allotropes: diamond and graphite
Chemical Reactions and Energy	Electrical nature of matter: electrification, electric discharge, conductors and insulators, and electricity and safety Chemical reactions: chemical equations, types of chemical reactions, and rate of chemical reactions Acids, bases, and salts: acidic and basic solutions, acidity and the concept of pH, and salts Applications
	Physics
Mechanics	Motion and speed Force: effects and classification Work, power, and forms of energy
Heat	
Waves	Characteristics of waves: sound waves Electromagnetic waves and colors
Optics	Rectilinear propagation of light Reflection of light and plane mirror

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Time

The instructional time in mathematics and science per week and per year at various levels is presented in Exhibits 5–7.

Exhibit 5 Basic Education: Distribution of Mathematics Periods

	Elementary Level						Intermediate Level		
	First Cycle			Second Cycle					
Grades	First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth	Ninth
Number of Periods Per Week	5	5	5	5	5	5	5	5	5
Number of Periods Per Year	150	150	150	150	150	150	150	150	150

Exhibit 6 Basic Education (Elementary Level): Distribution of Science Periods

Elementary Level						
	First Cycle			Second Cycle		
Grade	First	Second	Third	Fourth	Fifth	Sixth
Number of Periods Per Week	2	2	3	4	4	5
Number of Periods Per Year	60	60	90	120	120	150

Exhibit 7 Basic Education (Intermediate Level): Distribution of Science Periods in Grades 7 to 9 by Subject

Intermediate Level									
Grade	Seventh			Eighth			Ninth		
Subject	Physics	Chemistry	Life and Earth Sciences	Physics	Chemistry	Life and Earth Sciences	Physics	Chemistry	Life and Earth Sciences
Number of Periods Per Week	1.5	1.5	3	2	2	2	2	2	2
Number of Periods Per Year	45	45	90	60	60	60	60	60	60

Instructional Materials, Equipment, and Laboratories

In public schools, only books produced by the ECRD are used. In private schools, every institute is allowed to choose books produced by either the ECRD or private publishers.

Grade at Which Specialist Teachers for Mathematics and Science Are Introduced

In cycles 1 and 2 of basic education (elementary level), mathematics and science courses are given by nonspecialized teachers. The same teacher may, for instance, teach mathematics, science, and language courses. In cycle 3 (intermediate level), there are two classes of teachers: nonspecialized and specialized. All teachers in secondary education must be specialized. A teacher who teaches a chemistry course, for example, must be a university graduate with a degree in chemistry.

Use of Technology

The curriculum designates weekly periods for teaching students use of 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.

Homework Policies

The curriculum does not contain anything specific about homework. However, in actual practice, homework is given to students in cycles 1 and 2 once or twice a week, depending on the course and available teaching hours. Homework is corrected and evaluated by teachers. In cycle 3, homework is given in the form of exercises and cases to be prepared at home for subsequent correction.

Currently, an evaluation system is being developed by the ECRD. This project looks at homework assignments in terms of how much is assigned, the types of homework, and the evaluation methodologies used.

Teachers and Teacher Education

Education and Training for Fourth and Eighth Grade Mathematics and Science Teachers

As indicated above, teachers of mathematics and science in cycles 1 and 2 (elementary level) are not specialized. They fall into the following two categories.

- *Category 1*: Teachers who are graduates of teacher education centers and either have gone through 3 years in the center after obtaining their intermediate school certificate or have completed a year and a half in the center after obtaining their secondary school certificate and are trained to teach all courses (except languages).
- *Category 2*: Teachers who have obtained their secondary school diplomas and have not joined the centers but have gone on to take university courses.

Cycle 3 (intermediate level) teachers fall into the following three categories.

- For categories 1 and 2, see above.
- *Category 3*: Teachers in the public sector who either have a university degree in teaching courses or are graduates of the Faculty of Education. In the private sector, the first category (graduates of the centers) does not exist. Most teachers belong to either categories 2 or 3 (i.e., they are officially recognized as teachers on contract with private schools).

At present, the government carries out examinations to appoint specialized teachers at secondary schools who are required to have university degrees in the courses they are to teach. Such an arrangement has been devised to fill the vacancies resulting from the growth of public school attendance, particularly at the intermediate and secondary levels. These teachers have to go through a preparatory period of a year at the Faculty of Education to qualify for a teaching diploma in the relevant specialty.

Teacher Professional Development in Mathematics, Science, and Technology

Since the 1998–1999 school year, all teachers have gone through training sessions and are required to attend refresher training sessions. Teachers of mathematics and science attend special training sessions in laboratories on teaching and learning with active methodologies. 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 the use of technology and information and communication technology, the ECRD conducts training sessions at teacher training centers and secondary schools, as well as other public schools throughout the school year, outside of official working hours.

Examinations and Assessments

National or Regional Examinations

There are three types of examinations: school, official, and central official examinations.

- **School examinations in public schools**. Students in cycles 2 and 3, as well as secondary level students, sit for two examinations during the school year, in addition to monthly tests.
- **Official examinations at private schools**. 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 Lebanon in public or private schools have to sit for 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 have to sit for this examination with its four tracks (general science, life sciences, economics/sociology, or arts/humanities) to obtain a General Secondary School Certificate.

Students may not enter a university unless they obtain the General Secondary School Certificate. It should be noted that students' school results are not taken into account in official examinations.

Grade Promotion and Retention Policies

In public schools, a student is promoted to the next grade or repeats the same grade, based on the results of the examinations and tests mentioned above. However, in cycle 1, the student is automatically promoted. (The weaker students are subject to a booster program at the school.) In private schools, the decision to promote or not to promote a student is made in light of the same tests and examinations administered to public school students.

Suggested Reading

Educational Center for Research and Development: www.crdp.org

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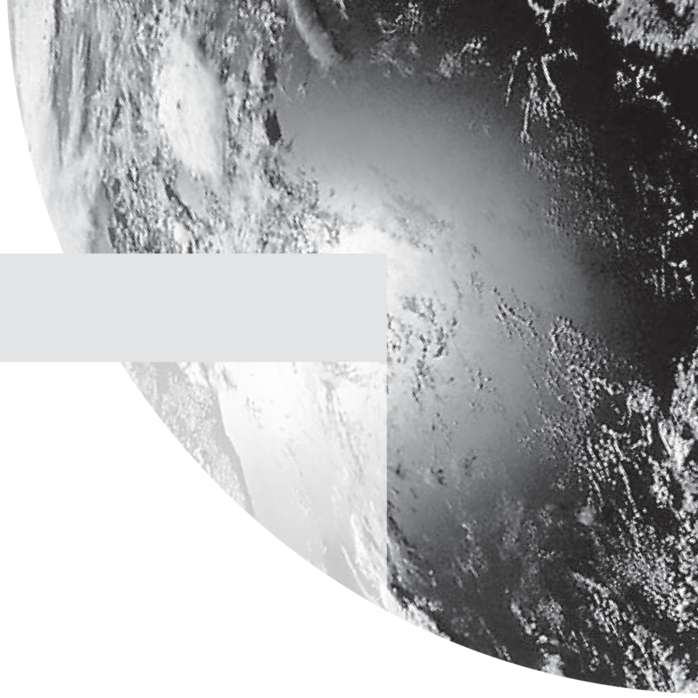

Lithuania

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Ministry of Education and Science

Introduction

Overview of Education System

In Lithuania, the Parliament defines the basic principles, structure, and objectives of education while the Ministry of Education and Science, with its institutions, devises and implements education policy. The ministry plays an important role in the education system. For example, it defines the curriculum, including mathematics and science, which is used throughout the country. It also determines teachers' salaries, requirements for teachers' qualification, priorities for qualification development, and the assignment of educational staff. However, the administration and financing of most general and vocational education schools (except some national-level schools) is the responsibility of local municipalities.

Preprimary education in Lithuania is optional and is intended for children ages 1 to 6. At present, it mainly consists of public and some private kindergartens. After a drop in attendance from 1991 to 1999, attendance has been increasing since 1999, with 64 percent of children age 5, and 78 percent of children age 6 attending kindergarten in 2006.[1]

Primary school consists of grades 1 to 4. Lower secondary school, or basic education, consists of grades 5 to 10. Education is compulsory for all students up to the age of 16. Enrollment in primary school is 98 percent of the total age group.[2] Primary and basic schools follow a national curriculum that is the same throughout Lithuania. The schools and teachers, however, are expected to adapt it to their own particular needs.

Upper secondary school consists of grades 11 and 12. In parallel to these schools, there are *gymnasiums*, which are 4 years and correspond to grades 9 to 12 of secondary school. *Gymnasiums* offer general education at a more advanced level than in secondary schools.

After significant changes in the political and economical system in Lithuania, changes in the education system also were inevitable, including changes to the structure, content, and teaching methods in Lithuanian schools. Specifically, these changes included more use of active teaching methods and freedom for schools and teachers to creatively look at the curriculum and educational materials and adopt them to the needs of students. The curriculum is reviewed every 4–6 years in order to adapt it to the changing needs of society.

Language and Population

Lithuania's official state language is Lithuanian. The main languages of minorities include Russian and Polish. In most of the schools, the language of instruction is Lithuanian, but there still are a considerable number of schools where the language of instruction is in other languages—mainly Russian or Polish. However, these schools also teach Lithuanian as a state language.

In primary and basic schools, mathematics and science are taught in the language of instruction of the school. However, in the upper classes, social subjects often are taught in the state language. In most cases, new textbooks are not translated into the minority language. Students themselves prefer to study these subjects in the state language.

Emphasis on Mathematics and Science

There is strong emphasis on learning mathematics. In Lithuania, many students, after finishing their secondary education, proceed to universities, and it is a requirement at many universities that students have good results in mathematics examinations. The majority of students in secondary school choose to study a higher-level mathematics course. The same cannot be said about science. However, there are a number of initiatives to promote mathematics and sciences at schools. These include various competitions, from traditional Olympiads that are more oriented towards very gifted students to the ones that most students find attractive and achievable and serve to promote interest in these subjects.

Overarching Policies Related to Education and the Curriculum for Mathematics and Science

After the first TIMSS cycle, the low results of Lithuanian students were much discussed in the educational community. Therefore, there were significant changes to the curriculum, textbooks, standards, and methods of teaching mathematics and science, and the emphasis was shifted to more practical applications instead of just theoretical knowledge. The academic way of presenting information was replaced by a more student-oriented teaching approach that took into account the age and experience of students.

The Mathematics Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Mathematics Through Eighth Grade

The main goal of mathematics education in the primary school, as declared in the official National Curriculum,[3] is to make it possible for students to develop the basics of mathematical literacy. This implies developing knowledge and skills that are necessary for solving students' everyday problems, further studies, diverse learning activities, as well as certain attitudes. The general goals of mathematics education in primary school are the following: develop students' mathematical problem-solving, reasoning, and communication skills; help students learn mathematical concepts and procedures so that they can understand the relationships involved and be able to use this knowledge; and develop interest in and a positive attitude toward mathematics.

In the case of basic education, the main purposes of mathematics education, as declared in the curriculum, are threefold: ensure that all students achieve a certain level of mathematical literacy; develop mathematical abilities, provide possibilities for gifted students to discover, and demonstrate their abilities; and develop a positive attitude toward mathematics, appreciating its beauty and practical usefulness. Therefore, the general goals of mathematics education in the basic school are to provide possibilities for students to develop their general mathematical skills; develop specific mathematical skills related to various areas of mathematics; investigate mathematics; and form attitudes and values declared in the content of general education.

In Exhibit 1, the main content areas and expected outcomes in mathematics by the end of **grade 4** are detailed. Students are expected to develop skills and abilities in the following content areas.

Exhibit 1 Mathematics Curriculum in Grade 4 in Lithuania

Mathematical Investigation and Applications	
Be able to mathematically model everyday life situations and solve problems, applying the simplest problem-solving strategies	Use elements of mathematical reasoning in the simplest situations Communicate using elements of mathematical language
Positive Numbers and Operations	
Understand the relative size of a number and the effect of arithmetical operations on them Relate numbers and elementary arithmetic operations to concrete objects and situations of close surroundings See the possibilities of computation applications and apply them when solving everyday life and mathematical problems	Estimate the amount of things from their surroundings; in simple cases, estimate the results of computations Choose an appropriate way of calculating (both in regard to the problem and the student)
Measurement and Geometry	
Describe the form of and position between the objects from their surroundings, as well as classify them Understand the need for measurement units and the relationship between them, as well as how to use them to describe results of measurement When measuring, be able to determine the parameters of objects from their surroundings and situations (such as length, weight, volume, temperature, speed, etc.)	Apply standard procedures of calculating perimeter and area when solving practical and mathematical exercises and problems Estimate (without measuring) parameters of the objects from their surroundings and situations (length, weight, and volume) Depict geometrical figures
Elements of Algebra	
Use number order relationships to compare numbers and quantities Compare numbers and quantities by depicting them graphically	Recognize, define, and apply simple relationships, laws, rules, or structures for describing practical situations Apply formal and informal ways of solving equations
Elements of Statistics	
Plan and carry out a survey Collect, put in order and analyze data, and make conclusions	Read tables and diagrams Depict results of surveys by tables and diagrams

In Exhibit 2, the main content areas and expected outcomes in mathematics by the end of **grade 8** are detailed. Students are expected to develop skills and abilities in the following content areas.

Exhibit 2 Mathematics Curriculum in Grade 8 in Lithuania

Mathematical Investigation and Applications	
Communicate using mathematical language Apply thinking strategies and procedures that are characteristic of mathematics	Identify and formulate problems, as well as investigate and solve them using mathematical methods Know and apply inner and outer mathematical connections
Numbers, Operations, and Percentages	
Understand, read, depict, and use numbers in various forms in the context of real life and in mathematical and other subject areas' exercises and problems Complete arithmetic operations with numbers and see the relationship among the main operations Choose an appropriate calculation way and method Give a prognosis of the results of calculations	Understand and use concepts of number theory for solving exercises and problems in various contexts Express the percentage of a number as a product of that number and as a fraction Apply calculations, estimations, percentages, and proportions in solving various problems
Measurement and Geometry	
Recognize, describe, compare, classify, and depict geometrical figures Understand the relationship between measurement units and various measurement ways Make direct and indirect measurements When making measurements, use appropriate units and tools	Understand formulas and procedures for calculating and estimating various measures Estimate and compare results of measurements Understand and apply geometrical qualities and relationships and measures and measurements when solving real-life, mathematical, and other subject areas' exercises and problems
Algebra, Functions, and Relationships	
Understand and use algebraic symbols, concepts, and methods Reorganize algebraic expressions and calculate their numerical value Make simple equalities, inequalities, or their systems and apply formal and informal methods for solving them	In various ways, write and analyze the relationship of two variables Understand the essence of proportions Use the main concepts related to functions and read graphics of functions and use them when answering simple questions in real-life situations
Statistics, Combinatorics, and the Probability Theory	
Understand what data is, how it is collected, ordered, and written down in frequency tables Understand what is represented by a diagram and represent data using an appropriate diagram Interpret data and make conclusions based on data analysis	In various ways in real situations, count the number of sets Understand what an experiment is and the set of outcomes Have an understanding about random events and ways to find their likelihood

The Science Curriculum in Primary and Lower Secondary Grades

Summary of National Curriculum Guides for Science Through Eighth Grade

The field of science in the general curriculum and the educational achievement standards are divided into the following four interrelated components: science investigation (integrated into other components), life science (biology), materials and their changes (chemistry), and physical phenomena (physics and astronomy).

The general objectives of natural sciences education at primary and basic levels are to provide students with an opportunity to experience the joy of discovery and understand the unity, harmony, and diversity of the universe; develop aspiration for lifelong learning and skills, collect science data from all the sources available, make an analysis and critical assessment, and comprehend and apply it in further studies or day-to-day life; plan explorative and environmental activities; take action and a critical approach to its results; understand a human being as a biological and social being and the role and place of man in nature; and develop skills to foresee the consequences of lifestyle on one's health, take responsibility for the protection of the environment, and get actively involved in addressing environmental issues.

In Exhibit 3, the main content areas and expected outcomes in science by the end of **grade 4**, respectively, are detailed. Students are expected to develop skills and abilities in the following content areas and subareas.

Exhibit 3 Science Curriculum in Grade 4 in Lithuania

Subarea	Science Investigation
	Conduct simple observations and experiments with the help of a teacher Find appropriate information and present it
	Life Science
Organism	Understand an organism as an interrelated, well-functioning system Indicate why it is important to take care of our own and other people's health and how to do that
Continuation and Diversity of Life	Describe the diversity of life and survival in nature
Organism and the Environment, Biosphere and Humans	Indicate the dependence of living things on the living and nonliving environment Indicate ways for decreasing environmental pollution
	Materials and Their Changes
Materials and Their Properties	Sort different materials into groups according to their properties and explore them
Changes of Materials	Indicate how and in which situations properties of materials are changed
Main Materials and Their Use	Explain that materials are used according to their properties Indicate sources of environmental pollutants and suggest ways for protection of one's own nearest environment
	Physical Phenomena
Motion and Forces	Describe motion
Energy and Physical Processes	Indicate the main energy resources and suggest ways of energy preservation
Earth and the Universe	Describe the Earth and the solar system

In Exhibit 4, the main content areas and expected outcomes in science by the end of **grade 8**, respectively, are detailed. Students are expected to develop skills and abilities in the following content areas and subareas.

Exhibit 4 Science Curriculum in Grade 8 in Lithuania

Subarea	Science Investigation
	Conduct observations and experiments and present results orally and in writing Measure some physical quantity with a simple measuring instrument Use basic units and dimensions of measuring Use school equipment for science research, chemical materials, and simple measuring instruments Independently find appropriate information from various sources, generalize, classify, and present it
	Life Science
Organism	Describe levels of organism structure and their functions Describe the structure of organisms and relate it to vital functions that are carried out by it Understand why it is important to take care of our own and other people's health
Continuation and Diversity of Life	Describe reproduction as one of the principal processes in supporting life's diversity and survival Describe the diversity of various features of plants and animals as a result of the process of evolution
Organism and the Environment, Biosphere and Humans	Describe the role of plants in nature and relationships between organisms and their relations with the nonliving environment Describe movement and transferring of substance and energy in ecosystems Describe main environmental problems and suggest ways for solving them
	Materials and Their Changes
Materials and Their Properties	Explain that materials are composed of interrelated particles Use information from the periodical table of elements and apply this in practice Separate mixtures of materials
Changes of Materials	Describe changes of materials and give examples
Main Materials and Their Use	Make solutions and describe acid and basic solutions Explore properties of materials and describe properties of main materials and their use Estimate the influence of human activities to environment
	Physical Phenomena
Motion and Forces	Describe the interaction between objects by using a concept of force, types of forces, and simple mechanisms and advantages of their use in engineering, as well as pressure and Archimedes force
Energy and Physical Processes	Describe and calculate mechanical work, power, and the efficiency coefficient Give examples for the display of the law of conservation of energy Separate reversible and nonreversible energy resources and describe the damage to nature caused by using nonreversible resources Describe mechanical waves Describe optical phenomena
Earth and the Universe	Describe the Earth, its location, and movement in the solar system and in a general outline, the solar system itself, stars, and galaxies

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Time

The main policies in relation to instructional time are outlined in the educational plans.[4] The school year in Lithuania begins on September 1 and usually ends at the end of May in primary school and around the middle of June in lower and upper secondary school.

Generally, school is in session in Lithuania 5 days a week. The instructional time is usually divided into subject lessons, each lesson lasting 45 minutes. For the fourth grade, in a typical week, the total amount of instructional time is approximately 17 hours. The maximum number of compulsory lessons per week varies from 23 lessons in grade 4 to 31 lessons in grade 8. This does not include some additional lessons that students are free to choose from depending on their availability at a particular school.

The number of lessons allocated for mathematics instruction is four to five per week in primary school, and for grades 5–8, four lessons per week. The number of lessons allocated for science instruction in primary school is two per week. In grades 5–6, it is also two per week, and in grades 7–8, on average, four lessons per week, consisting of biology, physics, and chemistry lessons.

Instructional Materials, Equipment, and Laboratories

Textbooks, exercise books, and teachers' books are still the main instructional materials for teaching mathematics and science, both for integrated science courses in earlier grades and for subject areas. In most cases, several types of textbooks can be chosen by the teacher to use in instruction. Usually, teachers use one textbook as a main teaching tool and other textbooks as supplementary materials. All textbooks and educational computer programs have to receive approval from the expert boards of the Ministry of Education and Science. Other materials do not need to be approved.

Many schools still have some old laboratories and equipment. There is a need for these teaching tools, and as a result, a number of projects recently were started to supply schools with laboratories and equipment for teaching science. However, this did not occur in time for TIMSS 2007.

Grade at Which Specialist Teachers for Mathematics and Science Are Introduced

In primary school, the same teacher provides instruction in both mathematics and science. However, beginning in grade 5, specialist teachers are used for both mathematics and science. Usually, the integrated science course in grades 5–6 is taught by a teacher of one of the science subjects. Beginning in grade 7, as soon as subject lessons start, instruction is given by teachers of these concrete subjects.

Use of Technology

In 2007, information technology was taught beginning in grade 9. Therefore, the use of computers in teaching other subjects in earlier grades was very limited.

Some computer programs that can be used in teaching science are starting to appear, but very few are in the Lithuanian language, and their use still is very limited. Most programs are in either English or Russian, but these programs are used sparingly. In mathematics, there are some programs in Lithuanian; however, since teachers are not trained to use them, computer programs often are not included in mathematics instruction.

In 2007, there were virtually no possibilities for distance learning at this stage of education, but at the moment, a number of projects are being developed that include distance learning, electronic teaching tools preparation, and teacher training in their use.

Homework Policies

In primary school, it is not recommended that homework be assigned. In other grades, there are certain limitations for homework assignments, defined in the educational plans. For example, teachers are asked not to assign homework before weekends and holidays. Teachers who are teaching the same classes are expected to coordinate the assignment of homework.

Teachers and Teacher Education

Education and Training for Fourth and Eighth Grade Mathematics and Science Teachers

Primary school teachers are trained either at the pedagogical universities or teacher training colleges. The courses include training in the subjects that are taught at the primary level, as well as the general courses of pedagogy, psychology, etc.

Basic school teachers are trained either at pedagogical universities or general universities by completing professional teachers' studies in addition to their bachelor studies. In the case of science teachers in pedagogical universities, they usually are trained in two subject areas, for example, biology and chemistry or physics and technology. Teachers are expected to teach the subjects in which they received training.

The majority of the teachers in general education schools (about 90%) have a university-level education, about 8 percent have a college-level pedagogical education, and about 2 percent have a secondary-level education.[5] About 97 percent of teachers in primary school and 93 percent of teachers in basic school have pedagogical qualifications.[6]

Teacher Professional Development in Mathematics, Science, and Technology

Qualifications and further education of teachers are provided mainly by the Teachers Professional Development Center and various teacher professional development training centers. Since 1993, professional development of the teachers in Lithuania has been encouraged through the assignment of the following qualification categories: teacher, senior teacher, teacher-methodologist, and teacher-expert. The teachers who have none of these qualifications are regarded as uncertified. In 2006, 20 percent of teachers were uncertified. Teachers' salaries in public schools depend mainly on their qualification category and length of service. Teachers must be recertified every 5 years, either to confirm their present category or receive a higher one. So far, the majority of teachers have received the senior teacher category, about 20 percent have the teacher-methodologist category, and only about 1 percent are in the highest category, teacher-expert. The teacher and senior teacher categories can be received at the school, and the higher categories through the boards at regional and national levels.

Examinations and Assessments

National or Regional Examinations

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). There are two examinations at the end of the basic school: mother tongue and mathematics. In addition, students of language minority schools also take the Lithuanian language examination. Examinations at the end of basic school are not high-stakes examinations, since their results are not used for selection purposes. Students who do not pass the examinations still receive their basic school-leaving certificates, provided they have acceptable school marks.

At the end of secondary school (grade 12), the range of final examinations is much wider. The Lithuanian language (either as a mother tongue or as a state language) is the only compulsory examination. Students are free to choose other examinations from a large list of examinations. Most examinations can be taken as state or school examinations. The tests and marking instructions for school examinations are prepared centrally by the National Examinations Center but are marked at the school. The tests for the state examinations are both prepared and marked centrally. The secondary school-leaving examinations are high stakes, since their results are used for selection purposes to enter higher-level educational institutions. Presently, Lithuania is preparing to review its examinations and make some changes to the examination system.

Other Tests

National sample surveys in mother tongue, mathematics, science, and social science are conducted in grades 4, 6, 8, and 10. These provide national-level information in the main areas of education. Occasionally, in some districts, all students are tested in order to monitor schools' situations and make educational management decisions. After the surveys, open questions with scoring instructions and national level statistics are made available and can be used by teachers to measure the relative achievement of their students. However, the area of standardized tests or diagnostic testing in Lithuania has not been developed.

Monitoring Individual Student Progress

Students in the primary school (grades 1–4) do not receive marks but receive written detailed explanations of their achievement based on teachers' observations. Beginning in grade 5, after a transitory period that lasts about half a year, marks from 1 to 10 are used to measure the attainment of students. General directions on what marks should be assigned for a particular level of attainment are provided, but usually, they are determined by the professional opinion of the teacher.

Grade Promotion and Retention Policies

In primary school, students usually pass to the next grade without being retained. If students have problems, the program can be modified or adapted. In basic school, if a student does not have a satisfactory mark in at least one of the subjects, teachers can suggest that a student stay in the same grade for another year, but only if parents agree.

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