TRENDS IN INTERNATIONAL MATHEMATICS AND SCIENCE STUDY

TIMSS

TIMSS 2011 Encyclopedia

Education Policy and Curriculum in Mathematics and Science

Volume 1: A–K

Edited by:

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

TIMSS & PIRLS
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TIMSS 2011 Encyclopedia: Education Policy and Curriculum in Mathematics and Science (Volumes 1 and 2)
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Foreword

For more than 50 years, the International Association for the Evaluation of Educational Achievement (IEA) has been instrumental in developing an analytical model for understanding the relationships between educational policy (the intended curriculum), classroom and instructional practices (the implemented curriculum), and educational learning outcomes (the achieved curriculum).

The *TIMSS 2011 Encyclopedia* describes the intended curriculum in the countries and sub-national jurisdictions that participated in the TIMSS 2011 assessment, providing a detailed description of the national contexts for the teaching and learning of mathematics and science. Each TIMSS 2011 participant contributed a chapter to this volume summarizing the overall structure of its education system, its mathematics and science curricula and instructional approaches at the primary and lower secondary levels, its requirements for teacher preparation, and the types of assessments and examinations that are employed to monitor educational outcomes at the national level.

The policy-related information provided in the *TIMSS 2011 Encyclopedia* is intended to complement the data on educational outcomes that are provided in the companion reports, *TIMSS 2011 International Results in Mathematics* and *TIMSS 2011 International Results in Science.* This information may be used not only to help understand the relationships among policies, practices, and outcomes within countries, but also to provide potentially powerful insights into international best practice.

Since its inception, TIMSS has relied on the extraordinary skill and professionalism of the staff at the TIMSS & PIRLS International Study Center at the Lynch School of Education, Boston College who provide the overall leadership for the project. In particular, IEA is indebted to the intellectual and organizational leadership provided by the TIMSS Executive Directors, Ina Mullis and Michael Martin, who have ensured the remarkable achievements of this project.

As well as the staff at Boston College, other key members of the consortium that conducts the TIMSS assessments, including Statistics Canada, Educational

Testing Service, the IEA Secretariat, and the IEA Data Processing Center, continue to make indispensable and exceptional contributions to the conduct and success of TIMSS. Ultimately, however, much of the credit for the content of the Encyclopedia must be reserved for the authors of the chapters who made this publication possible. Their efforts were supported by Chad Minnich, Gabrielle Stanco, Victoria Centurino, Alka Arora, and Courtney Castle, who were responsible for editing the chapters and preparing the data for this volume. Paul Connolly oversaw and coordinated the publication of the Encyclopedia, which was designed by Mario Pita and Ruthanne Ryan, with production assistance provided by Susan Farrell, Jen Moher Sepulveda, and Steven Simpson.

IEA is very grateful to the members of the IEA Publications Committee who reviewed each chapter and provided valuable guidance for improvement, and in particular for the long-standing service of David Robitaille and Robert Garden. IEA continues to be thankful for the financial support it receives in order to make a project of this magnitude possible. The U.S. National Center for Education Statistics continues to provide critical financial support and remains IEA's major funding partner. The World Bank also plays an important funding role by providing support for a number of its partner countries. The support provided by these institutions, together with that of countries contributing by way of participation fees, has ensured the successful completion of the TIMSS 2011 assessments.

Finally, I would like to express my thanks to the National Research Coordinators, whose responsibility it was to manage and conduct the study at the national level and who ensure the operational success of TIMSS. These individuals, together with policymakers and researchers in participating countries who provide critical support, combined with the willingness of principals, teachers, and students to participate, make possible not only the TIMSS assessments but also the basis for educational reform and improvement.

Hans Wagemaker
Executive Director, IEA

Introduction

The *TIMSS 2011 Encyclopedia* is a valuable compendium of how mathematics and science are taught around the world. Each TIMSS 2011 country and benchmarking participant prepared a chapter summarizing the structure of its education system, the mathematics and science curricula in the primary and lower secondary grades, and overall policies related to mathematics and science instruction (e.g., teacher education, materials, and assessment). The chapters were prepared from each country's viewpoint, written primarily by experts from ministries of education, research institutes, or institutions of higher education with extensive knowledge about their country's education system. Taken together, the chapters present a concise yet rich portrait of mathematics and science curricula and instruction around the world, and make the *TIMSS 2011 Encyclopedia* an indispensable resource for policy and research in comparative education.

Overview of TIMSS

IEA's TIMSS (Trends in International Mathematics and Science Study) aims to help countries improve teaching and learning in mathematics and science. TIMSS 2011 continues IEA's series of highly significant international assessments of mathematics and science. IEA (International Association for the Evaluation of Educational Achievement) pioneered international comparative assessments of educational achievement to gain a deeper understanding of the effects of policies and practices across countries' different educational systems. IEA is an independent international cooperative of national research institutions and government agencies, with nearly 70 member countries worldwide, a permanent secretariat in Amsterdam, and a thriving data processing and research center in Hamburg (the IEA DPC).

IEA began its pioneering work in the 1960s with an international study of mathematics achievement, and mathematics has remained a major focus throughout its 50-year history of educational research. First administered in 1995, IEA's TIMSS is an integrated assessment of mathematics and science that has been conducted every four years since then. TIMSS is directed by IEA's TIMSS & PIRLS International Study Center at Boston College.

As shown on the following page, 63 countries participated in TIMSS 2011, including some distinct education systems that always have participated separately throughout IEA's long history (e.g., the Dutch-speaking community of

Armenia
Australia
Austria
Azerbaijan
Bahrain
Belgium (Flemish)
Botswana
Chile
Chinese Taipei
Croatia
Czech Republic
Denmark
England
Finland
Georgia
Germany
Ghana
Honduras
Hong Kong SAR
Hungary
Indonesia
Iran, Islamic Rep. of
Ireland
Israel
Italy
Japan
Jordan
Kazakhstan
Korea, Rep. of
Kuwait
Lebanon
Lithuania
Macedonia
Malaysia
Malta
Morocco
The Netherlands
New Zealand
Northern Ireland
Norway
Oman
Palestinian Nat'l Auth.
Poland
Portugal
Qatar
Romania
Russian Federation
Saudi Arabia
Serbia
Singapore
Slovak Republic
Slovenia
South Africa
Spain
Sweden
Syrian Arab Republic
Thailand
Tunisia
Turkey
Ukraine
United Arab Emirates
United States
Yemen

Benchmarking Participants

Alberta, Canada
Ontario, Canada
Quebec, Canada
Abu Dhabi, UAE
Dubai, UAE
Alabama, US
California, US
Colorado, US
Connecticut, US
Florida, US
Indiana, US
Massachusetts, US
Minnesota, US
North Carolina, US

Belgium and Hong Kong SAR). In addition, TIMSS 2011 had 14 benchmarking participants, including three Canadian provinces, nine U.S. states, and two emirates from the United Arab Emirates. Countries and benchmarking participants could elect to participate in the fourth grade assessment, the eighth grade assessment, or both. Fifty-two countries and seven benchmarking participants administered the fourth grade assessment, and 45 countries and 14 benchmarking participants administered the eighth grade assessment.

Nationally representative samples of approximately 4,000 students from 150–200 schools participated in TIMSS 2011 at each grade level. More than 300,000 students participated in the TIMSS 2011 fourth grade assessment and a further 300,000 in the eighth grade assessment.

Demographics of the TIMSS 2011 Countries

The TIMSS 2011 participants were from all around the world (all continents except Antarctica), and represent a wide range of geographic and economic diversity. Because such factors as population size and, in particular, economic resources can impact educational policies, the following table presents selected information about the demographic and economic characteristics of the TIMSS 2011 countries, primarily reproduced from the World Bank's *World Development Indicators 2011*.[1] It can be seen that the TIMSS 2011 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. Nearly all of the countries had life expectancies of 69–83 years, and the majority had infant mortality rates of between 2 and 20 out of 1,000 births. However, Botswana, Ghana, South Africa, and Yemen had life expectancies of 52–63 years, and the highest infant mortality rates—between 43 and 51 out of 1,000 births.

Economic indicators, such as the data for gross national income per capita, reveal great disparity in the economic resources available among TIMSS 2011 countries, and also that different policies exist about the percentage of funds spent on education. Economically, the countries ranged from Kuwait, Norway, and the United Arab Emirates with relatively high gross national incomes per capita (above $50,000 USD, adjusted for purchasing power parity) to Georgia, Ghana, Honduras, Indonesia, Morocco, the Syrian Arab Republic, and Yemen with relatively low gross national incomes per capita (less than $5,000 USD, adjusted for purchasing power parity). Although half of the countries had 95 percent or more of their primary students enrolled in school, there was some

Selected Characteristics of TIMSS 2011 Countries

Country	Population Size (in Millions)[1]	Area of Country (1,000 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]	Public Expenditure on Education (% of GDP)[9]	Net Enrollment Ratio in Education (% of relevant group)[10]		Primary Pupil-Teacher Ratio[11]
										Primary	Secondary	
Armenia	3	30	108	64	74	20	3,100	5,410	3	84	87	19
Australia	22	7,741	3	89	82	4	43,770	38,510	5	97	88	–
Austria	8	84	101	67	80	3	46,450	38,410	5	–	–	12
Azerbaijan	9	87	106	52	70	30	4,840	9,020	3	85	93	11
[12] Bahrain	0.8	0.8	1,041	–	76	–	25,420	33,690	–	99	89	–
[13] Belgium (Flemish)	11	31	356	97	81	4	45,270	36,610	6	98	–	11
Botswana	2	582	3	60	55	43	6,260	12,840	9	87	60	25
Chile	17	756	23	89	79	7	9,470	13,420	4	95	85	25
[14] Chinese Taipei	23	36	639	70	79	4	16,471	34,520	4	98	97	16
[15] Croatia	4	57	79	58	76	5	13,770	19,200	5	91	92	11
Czech Republic	10	79	136	74	77	3	17,310	23,940	4	–	–	18
Denmark	6	43	130	87	79	3	59,060	38,780	8	95	90	–
[16] England	52	130	398	90	80	4	41,370	35,860	5	100	93	23
Finland	5	338	18	64	80	3	45,940	35,280	6	96	96	14
Georgia	4	70	61	53	72	26	2,530	4,700	3	100	81	9
Germany	82	357	235	74	80	4	42,450	36,850	5	98	–	13
[17] Ghana	24	239	105	51	57	47	1,190	1,530	6	76	46	33
Honduras	7	112	67	48	72	25	1,800	3,710	–	97	–	33
[18] Hong Kong SAR	7	1	6,721	100	83	2	31,570	44,540	5	94	75	16
Hungary	10	93	112	68	74	5	12,980	19,090	5	90	91	10
Indonesia	230	1,905	127	53	71	30	2,050	3,720	3	95	69	17
[19] Iran, Islamic Rep. of	73	1,745	45	69	72	26	4,530	11,470	5	99	74	20
Ireland	4	70	65	62	80	4	44,280	33,040	5	97	88	16
Israel	7	22	344	92	82	3	25,790	27,010	6	97	86	13
Italy	60	301	205	68	81	3	35,110	31,870	4	98	95	10
Japan	128	378	350	67	83	2	38,080	33,440	4	100	98	18
[20] Jordan	6	89	67	78	73	22	3,980	5,730	4	89	82	17
Kazakhstan	16	2,725	6	58	68	26	6,920	10,320	3	89	89	16
Korea, Rep. of	49	100	503	82	80	5	19,830	27,240	4	99	95	24
Kuwait	3	18	157	98	78	8	43,930	53,890	–	88	80	9
Lebanon	4	10	413	87	72	11	8,060	13,400	2	90	75	14
Lithuania	3	65	53	67	73	5	11,410	17,310	5	92	92	13
Macedonia, Rep. of	2	26	81	67	74	10	4,400	10,880	–	86	–	17
Malaysia	27	331	84	71	75	6	7,350	13,710	4	94	68	15
[21] Malta	0.4	0.3	1,297	–	80	6	18,360	23,170	6	95	80	11
[22] Morocco	32	447	72	56	72	33	2,770	4,400	6	90	79	27
Netherlands	17	42	490	82	81	4	48,460	39,740	5	99	88	–
[23] New Zealand	4	268	16	87	80	5	28,810	27,790	6	99	96	15
[24] Northern Ireland	2	14	133	63	80	6	41,370	35,860	5	98	99	20
[25] Norway	5	324	16	78	81	3	84,640	55,420	7	99	96	11
[26] Oman	3	310	9	72	76	9	17,890	24,530	4	77	82	12
[27] Palestinian Nat'l Auth.	4	–	693	74	72	21	1,749	–	–	91	68	–
Poland	38	313	125	61	76	6	12,260	18,290	5	95	94	10
[28] Portugal	11	92	116	60	79	3	21,910	24,080	5	99	88	11
[29] Qatar	1	12	122	96	76	10	71,008	–	–	93	77	11
Romania	21	238	93	54	73	10	8,330	14,540	4	90	73	16
[30] Russian Federation	142	17,098	9	73	69	11	9,340	18,330	4	94	–	17
Saudi Arabia	25	2,000	13	82	73	18	17,210	24,020	6	86	72	11
Serbia	7	88	83	52	74	6	6,000	11,700	5	94	90	16
[31] Singapore	5	1	7,125	100	81	2	37,220	49,780	3	100	98	19
[32] Slovak Republic	5	49	113	57	75	6	16,130	22,110	4	–	85	17
[33] Slovenia	2	20	101	48	79	2	23,520	26,470	6	97	91	17
South Africa	49	1,219	41	61	52	43	5,760	10,050	5	85	72	31
Spain	46	505	92	77	82	4	32,120	31,490	4	100	95	12
Sweden	9	450	23	85	81	2	48,840	38,050	7	95	99	10

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Selected Characteristics of TIMSS 2011 Countries (Continued)

Country	Population Size (in Millions)[1]	Area of Country (1,000 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]	Public Expenditure on Education (% of GDP)[9]	Net Enrollment Ratio in Education (% of relevant group)[10]		Primary Pupil-Teacher Ratio[11]
										Primary	Secondary	
Syrian Arab Republic	21	185	115	55	74	14	2,410	4,620	5	–	69	18
Thailand	68	513	133	34	69	12	3,760	7,640	4	90	71	16
Tunisia	10	164	67	67	74	18	3,720	7,810	7	98	71	17
[34] Turkey	75	784	97	69	72	19	8,720	13,500	4	95	74	22
Ukraine	46	604	79	68	69	13	2,800	6,180	5	89	85	16
[35] United Arab Emirates	5	84	55	78	78	7	54,738	59,993	1	90	83	16
United States	307	9,832	34	82	79	7	46,360	45,640	6	92	88	14
Yemen	24	528	45	31	63	51	1,060	2,330	5	73	–	–
Benchmarking Participants—Responses Pertain to Benchmarking Provinces/Regions/Emirates/States												
[36] Alberta, Canada	4	640	6	82	–	6	70,826	–	4	–	–	–
[36] Ontario, Canada	13	909	14	85	–	5	46,304	–	6	–	–	–
[36] Quebec, Canada	8	1,357	6	80	–	4	40,395	–	7	–	–	–
[37] Abu Dhabi, UAE	2	59	33	66	76	8	–	–	–	79	–	11
Dubai, UAE	–	–	–	–	–	–	–	–	–	–	–	–
[38] Alabama, US	5	82	58	55	75	10	32,661	–	–	–	–	15
[38] California, US	37	251	147	94	80	5	41,353	–	–	–	–	21
[38] Colorado, US	5	167	30	84	80	6	41,317	–	–	–	–	17
[38] Connecticut, US	4	8	451	88	80	7	53,573	–	–	–	–	14
[38] Florida, US	19	86	215	89	80	7	37,387	–	–	–	–	15
[38] Indiana, US	6	58	111	71	78	8	33,363	–	–	–	–	17
[38] Massachusetts, US	7	13	525	91	80	5	49,816	–	–	–	–	14
[38] Minnesota, US	5	128	41	71	81	6	41,223	–	–	–	–	16
[38] North Carolina, US	9	78	120	60	77	9	34,108	–	–	–	–	15

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

All data taken from the World Development Indicators 2011 (World Bank, 2011) unless otherwise noted.

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

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 part of their country of origin (pp. 10–13).

2 Area is the total suface area in square kilometers, including areas under inland bodies of water and some coastal waterways (pp. 10–13).

3 Midyear population divided by land area in square kilometers (pp. 10–13).

4 Urban population is the midyear population of areas defined as urban in each country and reported to the United Nations (pp. 166–169).

5 Number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life (pp. 118–121).

6 Infant mortality rate is the number of infants dying before reaching one year of age, per 1,000 live births in a given year (pp. 118–121).

7 GNI per capita in U.S. dollars is converted using the World Bank Atlas method (pp. 10–13).

8 An international dollar has the same purchasing power over GNI as a U.S. dollar in the United States (pp. 10–13).

9 Current and capital expenditures on education by local, regional, and national governments, including municipalities (pp. 76–79).

10 Ratio of total enrollment of children of official school age to the population of the age group that officially corresponds to the level of education shown (pp. 80–83). Please note that because educational systems vary in the ages and grades covered by primary and secondary education, World Bank ratios may underestimate actual net enrollment in some countries.

11 Primary school pupil–teacher ratio is the number of pupils enrolled in primary school divided by the number of primary school teachers (regardless of their teaching assignment) (pp. 76–79).

12 Net enrollment ratio in primary and secondary education taken from *Global education digest 2011* (UNESCO Institute for Statistics, 2011).

13 Figures for Belgium (Flemish) are for the whole country of Belgium.

14 All data taken from *2010 Social indicators statistics* (Directorate General of Budget, Accounting and Statistics, Executive Yuan, R.O.C., 2011).

15 Net enrollment ratio in secondary education taken from *Global education digest 2011* (UNESCO Institute for Statistics, 2011).

16 Population size and population density taken from Annual mid-year population estimates, 2010 (Office of National Statistics, 2011); Area of country taken from *The UK and its countries: Facts and figures* (Office of National Statistics, 2010); Urban population taken from OECD rural policy review, United Kingdom (OECD, 2011); Life expectancy at birth, gross national income per capita, and GNI per capita (purchasing power parity) reported for United Kingdom; Infant mortality rate taken from *Vital statistics: Population and health reference tables* (Office of National Statistics, 2011); Public expenditure on education reported for United Kingdom, taken from *UK Education expenditure as a proportion of GDP* (Department for Education, 2011); Net enrollment ratio in education reported for United Kingdom, taken from *Global education digest 2010* (UNESCO Institute for Statistics, 2010); Primary pupil-teacher ratio taken from *Education at a glance 2011: OECD indicators* (OECD, 2011).

17 Public expenditure on education taken from *The financing and outcomes of education in Ghana* (RECOUP Research Consortium, 2008).

18 Infant mortality rate taken from *Hong Kong monthly digest of statistics* (Hong Kong Census and Statistics Department, December, 2011).

19 Net enrollment ratio for secondary education taken from *Statistics of ministry of education* (Ministry of Education, Development Deputy, 2011).

20 Public expenditure on education and primary pupil-teacher ratio taken from *Jordan in figures 2010* (Department of Statistics, 2011).

21 Infant mortality rate taken from *Demographic review 2010* (Malta National Statistics Office, 2011); Public expenditure on education taken from *Expenditure on education as % of GDP or public expenditure* (Eurostat, 2008); Net enrollment ratio in secondary education taken from *Global education digest 2011* (UNESCO Institute for Statistics, 2011).

22 Net enrollment ratio in secondary education taken from *Anthology of education statistics 2010–2011* (Ministry of National Education, Division of Research and Statistics, 2011).

23 Net enrollment ratio in secondary education taken from *Global education digest 2011* (UNESCO Institute for Statistics, 2011).

Selected Characteristics of TIMSS 2011 Countries (Continued)

24 Population size and population density taken from *Annual mid-year population estimates, 2010* (Office of National Statistics, 2011); Area of country taken from *The UK and its countries: Facts and figures* (Office of National Statistics, 2010); Urban population taken from *Settlement population estimates, 2008* (Demography and Methodology Branch, NISRA, 2008); Life expectancy at birth, gross national income per capita, and GNI per capita (purchasing power parity) reported for United Kingdom; Infant mortality rate provided by Demography and Methodology Branch, NISRA; Public expenditure on education reported for United Kingdom, taken from *UK Education expenditure as a proportion of GDP* (Department for Education, 2011); Net enrollment ratio in primary education provided by Department of Education, based on number of students ages 4–10 enrolled in education divided by total number of children ages 4–10; Net enrollment ratio in secondary education provided by Department of Education, based on number of students ages 11–14 enrolled in education divided by total number of children ages 11–14; Primary pupil-teacher ratio provided by Department of Education.

25 Primary pupil-teacher ratio taken from *Education at a glance 2011: OECD indicators* (OECD, 2011).

26 Public expenditure on education taken from *Global education digest 2011* (UNESCO Institute for Statistics, 2011).

27 Population size, population density, and urban population taken from *Population, housing and establishment census, 2007* (Palestinian Central Bureau of Statistics, 2012); Life expectancy at birth and infant mortality rate taken from *Palestinian family survey, 2010* (Palestinian Central Bureau of Statistics, 2012); Gross national income per capita taken from the *Economic forecasting report 2012* (Palestinian Central Bureau of Statistics, 2012); Net enrollment ratio in primary and secondary education from *Educational database* (Ministry of Education and Higher Education, 2011).

28 Public expenditure on education taken from *Global education digest 2011* (UNESCO Institute for Statistics, 2011).

29 GNI per capita for 2009 taken from *World statistics pocketbook: Qatar* (United Nations Statistics Division, 2011).

30 Public expenditure on education and net enrollment ratio in primary education taken from *Global education digest 2011* (UNESCO Institute for Statistics, 2011).

31 Net enrollment ratio in education taken from Ministry of Education (2011).

32 Net enrollment ratio in secondary education taken from *Education at a glance 2011: OECD indicators* (OECD, 2011).

33 Public expenditure on education taken from *Expenditure for formal education, Slovenia, 2009* (Statistical Office of the Republic of Slovenia, 2009).

34 Public expenditure on education taken from *National education statistics formal education 2010–2011* (Ministry of National Education Strategy Development Presidency, 2011); Primary pupil-teacher ratio from *National education statistics formal education 2009–2010* (Ministry of National Education Strategy Development Presidency, 2010).

35 GNI per capita for 2009 taken from *World statistics pocketbook: United Arab Emirates* (United Nations Statistics Division, 2011); GNI per capita (purchasing power parity) taken from *National human development indicators: United Arab Emirates* (United Nations Development Programme, 2011).

36 Population, area of country, population density (2011), urban population (2006), and infant mortality rate (2008) provided by Statistics Canada; Gross national income per capita for 2010 taken from *Statistical report: PEA comparison tables – Per capita table* (Ministry of Finance, Office of Economic Policy, Economic and Revenue Forecasting and Analysis Branch, 2011). Please note gross domestic product is reported in place of gross national income and is in Canadian dollars. Public expenditure on education taken from *Education indicators in Canada: An international perspective 2011* (Canadian Education Statistics Council, 2011).

37 All data taken from Statistics Centre – Abu Dhabi (2011).

38 Population size taken from *Intercensal estimates of the resident population for the United States, regions, states, and Puerto Rico* (United States Census Bureau, 2011); Area of state taken from *Guide to state and local census geography* (United States Census Bureau, 2011); Population density taken from *United States: Population density by state* (United States Census Bureau, Population Division, 2009); Urban population taken from *Statistical abstract of the United States: 2012* (United States Census Bureau, 2011); Life expectancy at birth taken from *The Centers for Disease Contol and Prevention, National Center for Health Statistics mortality data and US Census Bureau population data, 2007* (statehealthfacts.org); Infant mortality rate from *National vital statistics report, Vol. 59, No. 6* (Centers for Disease Control and Prevention, National Center for Health Statistics, 2011); Gross National Income is substituted with Personal Income per Capita from the Bureau of Economic Analysis, U.S. Department of Commerce (2009); Primary pupil-teacher ratio includes public schools only, from *Numbers and Types of public elementary and secondary schools from the common core of data – School year 2009–10* (National Center for Education Statistics, 2011).

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

degree of variation in enrollment rates in primary education (e.g., 76–77% in Ghana and Oman). There were increases in dropout rates at the secondary level (although TIMSS is at the lower secondary level), but more than half of the countries had 85 percent or more of their secondary students enrolled in school.

The Importance of Country and School Contexts in Making International Comparisons

The results of high-quality international assessments such as TIMSS 2011 can make important contributions to improving educational quality. Yet, it must be kept in mind that countries are very different from one another in fundamental ways, and educational systems reflect these differences. 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 has the specific goal of increasing understanding of the effects of educational policies and practices within and across countries.

The *TIMSS 2011 Encyclopedia* provides an overview of the context in which learning mathematics and science takes place in each country. A country's education system is the result of a series of decisions made in response to the specific goals, priorities, politics, resources, and historical traditions of its government representatives and citizens, and the encyclopedia chapters provide an opportunity to better understand each country's contexts for mathematics and science instruction. Several of the regional benchmarking participants also have prepared chapters explaining their educational systems (i.e., the Canadian provinces of Alberta, Ontario, and Quebec) or how their systems relate to their national systems which also participated (i.e., the Emirates of Abu Dhabi and Dubai, and the U.S. state of Florida).

Each TIMSS assessment routinely includes a curriculum questionnaire to collect background information from each country and benchmarking participant about its mathematics and science curricula, school organizational approaches, and instructional practices. This curriculum data supports the encyclopedia chapters by providing some information about the participant's educational systems and curricula that can be answered in a questionnaire format. The results from the *TIMSS 2011 Curriculum Questionnaire* are presented following this introduction and, together with the countries' chapters, provide an important vehicle for beginning 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.

There is a distinction between overarching system-level decisions such as those described in the *TIMSS 2011 Encyclopedia* and what actually is taught in school and classroom situations. In IEA parlance, there is a difference between the intended curriculum, as specified in official documents, and the implemented curriculum that actually is taught in the schools. Thus, two companion TIMSS reports summarize the achievement results and the background data collected about school and classroom environments. The report titled *TIMSS 2011 International Results in Mathematics* summarizes fourth and eighth grade students' trends in mathematics achievement and provides considerable information about how mathematics is taught in schools.[2] The companion report, *TIMSS 2011 International Results in Science* contains fourth and eighth grade students' trends in science achievement and related data concerning science instruction.[3] To provide trends in mathematics and science achievement in the context of different schools and classrooms with diverse policies, practices, and resources, the students assessed in TIMSS as well as their teachers and school principals completed questionnaires about their school and classroom conditions, including the background and experiences of teachers and students. Much of this information is provided together with the TIMSS achievement results in the TIMSS mathematics and science reports. The *TIMSS 2011 Encyclopedia* provides a qualitative complement to the quantitatively oriented international reports, *TIMSS 2011 International Results in Mathematics* and *TIMSS 2011 International Results in Science*.

One of the most important uses of the *TIMSS 2011 Encyclopedia* is to gain a sense and appreciation of the uniqueness of each educational setting represented in TIMSS 2011. All of the countries have the common goal of teaching their students mathematics and science; yet national and regional contexts and instructional situations can differ dramatically depending on particular country characteristics, such as resources, culture, demographics, and educational philosophies.

The remaining sections of the introduction provide a flavor of the wide variety of educational contexts represented across the countries that participated in TIMSS 2011 by briefly summarizing information about the topics addressed in the chapters. After the introduction, the next part of the encyclopedia contains the *TIMSS 2011 Curriculum Questionnaire* data, followed by the country chapters in alphabetical order and the chapters by benchmarking participants.

Overview of the Education Systems

According to the country chapters, nearly all the education systems represented in TIMSS 2011 were managed by the central government, mostly by a single education ministry (although in several countries responsibilities were divided among two or three ministries). However, these countries reported a range in the degree of centralization in decision-making, from "highly centralized" (e.g., Austria, Honduras, Iran, Lebanon, the Syrian Arab Republic, and the Ukraine) to "decentralized" (e.g., the Czech Republic, Macedonia, New Zealand, and Sweden). With less centralization, typically the role of educational policy-making was maintained by the central government, while implementation of services (sometimes including administration and various levels of decision-making) was delegated to the regional or state level, or even to municipalities. For example, as Jordan explained: "A central principle of Jordan's educational policy is centralizing the general planning and follow-up of the education system while decentralizing its administration." In three TIMSS 2011 countries, education is managed at the state level, including Australia, Germany, and the United States. Countries' education systems often included private as well as public schools, and a number of countries mentioned vocational education at the secondary level.

Exhibit 1 from the *TIMSS 2011 Curriculum Questionnaire* (see section following the Introduction) shows that most of the TIMSS 2011 participants had formal policies to ensure parental involvement in schools. In approximately half of the countries, school governing bodies were mandated to include parents.

In general, the TIMSS 2011 participants structured their education systems according to three general levels of schooling—primary, lower secondary, and upper secondary. The TIMSS 2011 fourth grade students typically were a product of primary schools because primary education usually spanned Grades 1–4 or Grades 1–6, but there were variations. Some countries had a structure with only two levels, where the primary level spanned Grades 1–8 or 9. In these cases, the fourth and eighth grades were in the same level of education. However, the eighth grade students typically were in lower secondary school where the most common structure was Grades 7–9, but across countries lower secondary school started as low as Grade 5 and went as high as Grade 11. Exhibit 2, summarizing country's questionnaire responses, shows that schooling typically was compulsory through age 16 (with some variation), although most countries provided schooling through Grade 12 (again, with some variation).

Because the distribution of students' ages across and within grades is determined by the policy of age of entry to primary school (ISCED Level 1) and how this is implemented in practice, as well as by promotion and retention practices through the grades, Exhibit 3 summarizes countries' policies on age of school entry, the usual age of entry in practice, and promotion/retention from grade to grade. (Research based on PIRLS 2006 shows how the age of entry policies were related to fourth grade students' ages at the time of the assessment, with those fourth grade students entering school at younger or older ages generally being younger or older, respectively, at the time of the assessment.[4]) Although most children participating in TIMSS 2011 were required to enter school at age six or seven, there were variations in age of entry policies and in how the policies were implemented. There were also variations in promotion policies, from automatic for Grades 1–8 (e.g., Chinese Taipei) to "dependent on academic progress" beginning with Grade 1 (e.g., Italy).

A recent report from the Economist Intelligence Unit observes that preprimary or early childhood education has been becoming more prevalent internationally since the 1980's.[5] The report explains that early childhood education develops children's readiness for school and life, and has the additional benefits of facilitating more women to enter the workforce and helping children overcome issues related to poverty and disadvantage. Exhibit 4 shows the TIMSS 2011 countries' responses to the curriculum questionnaire questions about preprimary education, with all participants indicating that preprimary education was available. More importantly, in their encyclopedia chapters, many countries reported that even though preprimary education was voluntary, it was a very important part of the education systems. A number of countries reported that nearly all children attended preprimary education (e.g., the Dutch-speaking community of Belgium, Chinese Taipei, Croatia, England, Portugal, Romania, Singapore, and Sweden) beyond the ten countries reporting that preprimary education was mandatory (Exhibit 4). Most of the TIMSS 2011 participants had a national preprimary curriculum including both mathematics and science, although the level of the content and activities, undoubtedly, varies considerably.

Languages of Instruction

Most of the TIMSS 2011 countries reported one major language of instruction for mathematics and science, especially by the eighth grade. However, some countries delivered instruction in several languages, and a number mentioned providing instruction in several minority or regional languages in addition to the predominant language of instruction. (The *PIRLS 2011 Encyclopedia* includes more information about language and literacy in the primary grades.)

Selected Characteristics of Mathematics and Science Curricula in the Fourth and Eighth Grades

This section summarizes information about the mathematics and science curricula collected via the *TIMSS 2011 Curriculum Questionnaire*. Nearly all of the 2011 countries had a national curriculum for mathematics and for science (Exhibits 5 and 6). As explained in the chapters, for mathematics, even countries where educational decisions are made at the state rather than national level were moving towards more national uniformity in their curricula (i.e., the national statements in Australia moving toward a national curriculum, national standards in Germany, and the Common Core State Standards in Mathematics in the United States). As further explained in its chapter, Iran has a national science curriculum, but national guidelines for mathematics. At the fourth and the eighth grades, and for both mathematics and science, typically the curricula assessed in 2011 had been introduced since 2000, although more than half were under revision.

At the fourth grade, all of the mathematics and science curricula had goals and objectives, with more than half also including instructional methods and assessment standards, and somewhat less than half including instructional materials (Exhibit 7). Similarly, at the eighth grade, all of the mathematics and science curricula had goals and objectives, with more than half also including instructional methods and assessment standards, and about half instructional materials (Exhibit 8).

Every TIMSS 2011 country reported making its fourth grade mathematics and science curricula available via an official publication, with the exception of Iran's mathematics guidelines (Exhibit 9). Many also reported using ministry notes and directives. More than half of the mathematics and science curricula at the fourth grade were accompanied by mandated or recommended textbooks and instructional or pedagogical guides, while somewhat fewer than half had recommended instructional activities. The results were similar at the eighth grade (Exhibit 10), with every country producing a publication containing the eighth grade mathematics and science curricula (except Iran for mathematics), and more than half using ministry notes and directives. At the eighth grade, more than half of the mathematics and science curricula were accompanied by an instructional guide, and about half had mandated textbooks and instructional activities (especially in science).

Countries' mathematics curricula at the fourth grade placed "a lot" of emphasis on mastering basic skills, and "some" to "a lot" of emphasis on applying mathematics in real-life contexts (Exhibit 11). For reasoning mathematically, the degree of emphasis varied considerably across countries, from "very little" to "a lot." At the eighth grade, countries placed "some" to "a lot" of emphasis on basic skills, and indicated a wide range in the amount of emphasis placed on application and reasoning, from "very little" to "a lot" (Exhibit 12).

The emphases of science curricula at the fourth grade ranged from "very little" to "a lot" for each of the curriculum components queried: knowing basic science facts and principles, applying science in real-life contexts, providing explanations or justifications, designing and planning experiments, and conducting experiments (Exhibit 13). However, similar to the mathematics curricula, knowing basic science facts and application to real-life had greater emphasis (more "a lot" responses) than the other three science curriculum components. At the eighth grade, in general, "some" or "a lot" of emphasis was placed on knowing facts and application (Exhibit 14). Most countries also placed "some" or "a lot" of emphasis on justifying, designing, and conducting experiments, but some developing countries reported less emphasis on designing and conducting experiments as a result of lack of resources (see chapters).

At the fourth grade, most countries reported that mathematics and science curriculum implementation was monitored by curriculum inspectors or supervisors and school self-evaluation (Exhibit 15). Most countries also reported using national or regional mathematics assessments for curriculum monitoring, and about half used science assessments. About half of the countries reported monitoring mathematics and science curriculum implementation via research programs. At the eighth grade, most countries reported using a variety of methods to monitor mathematics and science curriculum implementation, and all the methods queried were widespread (Exhibit 16). Using national or regional mathematics assessments was more prevalent than science assessments, with school self-evaluation being somewhat more frequent for science than mathematics.

Mathematics Curricula in Primary and Lower Secondary Grades

This section summarizes countries' mathematics curricula as described in their chapters through the lens of the TIMSS 2011 Mathematics Framework.[6] At the fourth grade, the framework placed half of the assessment emphases on number, 35 percent on geometric shapes and measures, and 15 percent on data display, and this corresponds well with countries' reports.

Number topics comprise the majority of topics in the fourth grade mathematics curricula summarized in the chapters. Nearly all the curricula mentioned operations with whole numbers, two-thirds mentioned fractions and decimals, one-third mentioned patterns, and some mentioned multiples and factors. Interestingly, more than one-third mentioned algebra with most including simple linear equations. In geometric shapes and measures, about half of the fourth grade curricula mentioned identifying two-dimensional and three-dimensional shapes, as well as the perimeters and areas of two-dimensional shapes. One-third of the chapters mentioned particular geometric properties (i.e., parallel and perpendicular lines, line and rotational symmetry, and properties of angles and polygons). Some countries mentioned estimating volume and relating solids to their nets. Of the two-thirds that included data display in their curricular summaries, most mentioned tables and about half mentioned bar graphs and pictographs. Somewhat fewer countries mentioned basic probability and measures of central tendency (mean, median, and mode).

At the eighth grade, the TIMSS 2011 Mathematics Framework covers number (30%), algebra (30%), geometry (20%), and data and chance (20%), and countries typically reported more emphasis on algebra and geometry topics by the eighth grade. In number, more than half of the countries had introduced integers and irrational numbers, and half included ratios and proportions, operations with fractions and decimals, and exponents. There was considerable variation in algebra, but most countries had introduced linear equations. About half had introduced functions or equations with two variables and linear inequalities, and some described teaching quadratic equations or expressions. Geometry also evidenced variation, but about two-thirds of the countries mentioned relationships among angles and using formulas to calculate volumes and surface areas. From one-third to half mentioned the Pythagorean Theorem, reflection and translation, congruence, similarity, and Cartesian planes. Coverage of data topics showed the most variation across countries by grade. At the eighth grade, half of the countries mentioned collecting, organizing, and representing data meaningfully, in addition to bar graphs, pictographs, and pie charts (often fourth grade topics). Half or more included probability and measures of central tendency, which was a substantial increase compared to the fourth grade.

To be successful on the TIMSS 2011 assessment, students needed to be familiar with the mathematics content being assessed, but they also needed to draw on a range of cognitive skills. At both the fourth and eighth grades, TIMSS required students to apply their mathematics knowledge to a range of situations and to engage in reasoning and problem solving. Korea's chapter summarized as follows:

> A deep understanding of the application of mathematical concepts, including practical problem-solving abilities, is essential to learning diverse subjects and also is necessary for developing professional skills and the ability to solve problems as a democratic citizen.

About half of the chapters mentioned applying mathematics skills to real-life contexts as a goal of mathematics instruction. Also, half of the countries at the fourth grade and more than half at the eighth grade mentioned problem solving in their chapters, and about half at both grades explicitly mentioned that the aim of teaching mathematics was to inculcate critical thinking among students. For example, the Russian Federation mathematics curriculum includes the following:

> Intellectual development; the formation of characteristics necessary for a productive life in a modern society, such as clarity and accuracy of thinking, critical thinking, intuition, logical thinking, elements of algorithmic culture, spatial notions; and the ability to overcome difficulties.

Finally, the TIMSS 2011 framework describing the contexts for teaching and learning mathematics underscores the importance of students' motivation to learn. About one-fourth of the chapters mentioned that mathematics instruction should build an appreciation of mathematics and positive attitudes toward the subject.

Science Curricula in Primary and Lower Secondary Grades

This section summarizes countries' science curricula as described in their chapters in relation to the TIMSS 2011 Science Framework.[7] At the fourth grade, the framework devotes 45 percent of the science assessment to life science, 35 percent to physical science, and 20 percent to earth science.

Many countries' fourth grade science curricula in life science included characteristics of living things, and the interdependencies of living things (i.e., beginning ecosystems), and about half included human body function and nutrition and health issues. About one-third mentioned life cycles as well as plant structures and functions. In physical science, chemistry topics focused on materials (e.g., properties, uses, and states of matter). For example, Norway included: "Sort substances according to easily observable characteristics and describe the characteristics." The physics topics mentioned most often (in about one-third of the curricula) included light and sound, electricity and magnets, and energy and heat. Some chapters mentioned forces. In earth science, half of the chapters included conservation of the Earth's resources, and about one-third mentioned the solar system, weather and/or seasons, and the Earth's resources (e.g., water, air, soil, and minerals).

At the eighth grade, the TIMSS 2011 Science Framework covers biology (35%), chemistry (20%), physics (25%), and earth science (20%). In biology, the majority of the chapters covered human body systems (e.g., organ systems) and ecosystems. The building blocks of systems, such as cells, also were widely mentioned, as were nutrition and health issues. About one-third mentioned heredity (i.e., inheritance or genetics) and evolution and adaptation. Compared to the fourth grade, chemistry topics expanded to include classifying matter into elements, compounds, mixtures, and exploring its particulate structure (atoms and molecules). For example, Finland included the following:

> Symbolic designation, classification, and distinction of elements and compounds; and explanation of properties and structures of elements and compounds with the aid of an atomic model or the periodic table.

About one-fourth of the chapters specifically mentioned conservation of matter in conjunction with chemical change. In physics, two-thirds of the chapters included energy (and usually also heat), and about half included forces and motion, electricity and electric circuits, light and sound, and magnetism and electromagnetism. Half of the earth science curricula included conservation and human impact on the environment and the Earth's structure and composition, and nearly half mentioned the solar system and the Earth's processes and cycles (e.g., water cycle, rock cycle, and climate). Approximately one-third mentioned the Earth's resources.

In the TIMSS 2011 Science Framework, the processes of scientific inquiry were fundamental to all science fields. At both the fourth and eighth grades, TIMSS required students to apply their scientific knowledge to a range of situations and to engage in reasoning. Most of the countries' science curricula included inquiry skills. The fourth grade focused on testable predictions, observing and identifying patterns, providing evidence to support ideas, and designing and conducting simple experiments, mostly in the context of nature studies. The eighth grade inquiry skills were integrated across all content domains, and were more closely aligned with the scientific method—formulating hypotheses, designing experiments, collecting and analyzing data, making determinations based on the data, and communicating findings.

Perhaps surprising, considering the emphasis on preparing students in STEM subjects, only about one-fourth of the curricula specifically mentioned encouraging interest in science. On the other hand, about one-fourth mentioned a focus on science, technology, and society. For example, Australia included the following:

> Reflects on the way science influences society through its way of thinking and world view, as well as the way societal challenges or social priorities influence the development of scientific research.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Of the fourth grade countries with national policies allocating instructional time across curricular subjects, there was variation but most allocated 13–22 percent of fourth grade instruction time to mathematics instruction, and somewhat less time to science instruction, from 7–13 percent (Exhibit 17). There was variation among the eighth grade countries with national policies allocating instructional time across curricular subjects, but most allocated 10–18 percent of eighth grade instructional time to mathematics instruction (somewhat less than at the fourth grade) and several had the same policy for science (Exhibit 18). However, a set of countries allocated a greater amount of time in the eighth grade curriculum to science (24–28%), including Armenia, Kazakhstan, Macedonia, Romania, the Russian Federation, Slovenia, and the Ukraine.

Teachers' reports about instructional materials and computer use are published in the two TIMSS international reports: *TIMSS 2011 International Results in Mathematics* and *TIMSS 2011 International Results in Science.* For mathematics, internationally, on average, teachers used textbooks most often as the basis for instruction (for 75% and 77% of the fourth and eighth grade students, respectively) and workbooks or worksheets were used the next most often (for 46% and 34%) followed by concrete objects or materials (for 37% and 23%), and then computer software (for 9% and 7%). Typically, a variety of supplemental instructional materials were used in addition to the primary resource. For example, approximately two-thirds reported using concrete objects as a supplementary resource in mathematics instruction (for 62% and 71% of the fourth and eighth grade students, respectively) and about half using computer software (for 56% and 55%).

For science, the results were very similar, with textbooks used most often as the basis for science instruction (for 70% and 74% of the fourth and eighth grade students, respectively). However, whereas workbooks or worksheets were used the next most often at fourth grade (for 41%), science equipment and materials were used the next most often at the eighth grade (for 43%). Science equipment and materials were used as the basis of instruction for 36 percent of the students at the fourth grade. Relying on computer software was relatively rare, used for only 11 percent of the fourth grade students and 16 percent of the eighth grade students. However, teachers reported that all of the materials TIMSS asked about were used to some extent as supplementary resources for science instruction, with science equipment and materials the most popular (used with 60% and 54% of the fourth and eighth grade students, respectively) as well as computer software used with 53 percent of the fourth grade students and 61 percent of the eighth grade students.

According to the country chapters, mathematics and science textbooks often were supplied or selected by the ministry, although in about half of these countries the ministry provided approved lists for selection by schools or teachers. Exhibits 19 and 20 provide detailed information about procedures for textbook selection in the TIMSS 2011 countries.

In their chapters, the majority of countries described considerable school-wide emphasis on Information Technology, only sometimes mentioning uses specific to mathematics and science instruction. A few countries did report considerable use of computers and various technologies in mathematics and science instruction (e.g., Hong Kong SAR, Japan, Norway, and Singapore).

Exhibits 21 and 22 describe the national policies for calculator use at the fourth and eighth grades. At the fourth grade, most countries do not have a policy about calculator use in mathematics and science instruction, although a few begin instruction in the primary grades (e.g., England and Kazakhstan) and some have policies stating that calculators can be used starting in the fourth or fifth grades. At the eighth grade, a number of countries had policies encouraging calculator use. In their chapters, using calculators in mathematics instruction was mentioned by a number of countries, usually starting about in the fifth grade. Exhibits 23 and 24 describe the national policies for computer use at the fourth and eighth grades. At the fourth grade, nearly 20 countries reported "no policy" for both mathematics and science. However, the rest reported an emphasis on ICT that was not specific to mathematics or science. By the eighth grade, most countries had policies about developing ICT capabilities and some of these had policies specific to mathematics.

Taken together, the questionnaire responses and chapters with specifics for technology use in mathematics instruction, included the following purposes: making numerical calculations, representing data in tables and graphs, examining geometric figures, creating spreadsheets, analyzing data, investigating linear functions, and making connections between graphical and symbolic representations as well as algebraic and geometric ideas. For science, several countries specifically mentioned using the Internet in science instruction to collect information to research questions. Besides the Internet, computers were used for visualizing, simulations, tabulating data, and writing reports.

Across countries the range of computer availability was very large at both the fourth and eighth grades. Nevertheless, at fourth grade, on average across countries, teachers reported that about one-third of students were asked to use a computer at least monthly to practice skills and procedures, and about one-fourth to explore mathematics principles and concepts and to look up ideas and information. At the eighth grade, teachers reported that about one-fifth to one-fourth of students were asked to do the following on at least a monthly basis: explore mathematics principles and concepts, look up ideas and information, process and analyze data, and practice skills and procedures.

As part of fourth grade science instruction, teachers reported that about one-fourth of students were asked to use a computer at least monthly to do scientific procedures or experiments or study natural phenomena through simulations. Somewhat larger percentages were asked to use a computer at least monthly to look up ideas and information (41%) and to practice skills and procedures (31%). At the eighth grade, approximately one-third were asked to do the following on a monthly basis: look up ideas and information, do scientific procedures or experiments, study natural phenomena through simulation, process and analyze data, and practice skills and procedures.

Laboratory equipment plays an important part in science instruction, and many countries reported that all secondary schools had science laboratories, with a number also reporting that even primary schools had science laboratories. According to school principals, 36 percent of the fourth grade students and 80 percent of the eighth grade students attended schools with science laboratories (see *TIMSS International Results in Science*). In their chapters, some countries also reported having science classrooms equipped with a variety of science-oriented materials, such as thermometers, anemometers, barometers, magnifying glasses, representations of the solar system, and periodic tables. The Dutch-speaking community of Belgium reported that some schools have a school garden or a children's farm.

Homework is a way to extend instruction and assess student progress, and several countries reported that it was an integral part of the students' workbooks (e.g., Bahrain) and several mentioned using homework to provide feedback on student learning (e.g., Singapore and Yemen). However, many countries reported that there was no national policy about homework and that it was the teachers' responsibility to schedule homework according to their own professional judgment and criteria. Most of these commented, however, that assigning homework was a recommended or common practice, although more often in mathematics than science, and more often at the higher grades. The Korean chapter mentions that, in addition to standard instruction, many students take advantage of private education by attending "after-school classes."

The eighth grade students in TIMSS were asked how often their teacher gives homework in mathematics and in science, and how much time they usually spent on it when it was given. For mathematics, internationally, on average, only 15 percent of the eighth grade students reported doing as much as three hours of mathematics homework per week, 38 percent reported doing less than three hours but more than 45 minutes, and almost half (48%) reported doing 45 minutes or less. Students reported doing even less homework for science. Internationally, on average, only 5 percent of the eighth grade students reported doing as much as three hours per week, 29 percent reported doing less than three hours but more than 45 minutes, and 67 percent reported doing 45 minutes or less (see *TIMSS International Results in Science*).

Teachers and Teacher Education

In the chapters, countries reported that fourth grade students typically are taught mathematics and science by general purpose primary school teachers that are responsible for teaching all basic subjects. By the fifth or sixth grade, however, in about half of the countries students had specialist teachers in mathematics and science, and by lower secondary school, in nearly all of the countries students had specialist teachers in mathematics and science (typically seventh grade).

As described in the chapters (and in Exhibit 25), primary teachers' education routes typically were through a four-year university bachelor's degree program in primary education, although there was some variation. For example, several countries had three-year bachelor's degree programs or teacher colleges with a three-year diploma program, and several countries required primary school teachers to have master's degrees (e.g., Croatia and Finland). Some countries mentioned that primary teacher certification required passing a national examination, and several mentioned a one-year induction program.

Typically, the education requirements were similar for becoming a lower secondary school specialist teacher (see Exhibit 26), except as further explained in the chapters; additional training was required in mathematics or science. For example, in Finland teachers needed 160 credits in a major and 60 credits in a minor, compared to seven credits in mathematics and six in science to teach primary school. In general, to teach mathematics or science, teachers needed to have majored, minored, or taken a special program in those subjects. Alternately, teachers could have a university degree in mathematics or science together with education courses, a special one-year training program, or a diploma in education. Several countries required a university degree in mathematics or science (e.g., Kazakhstan, Italy, and Spain).

Since 2000, about one-third of the TIMSS 2011 countries have increased the requirements for becoming a teacher, especially at the primary school level. Approximately a dozen countries added an additional year or a degree requirement (e.g., extending programs from three to four years, or replacing teacher college diplomas with university bachelor's degrees). Croatia and Portugal reported new regulations requiring a master's degree. Also, several countries added examination requirements (e.g., Georgia added a national examination and the Netherlands added examinations in the Dutch language and mathematics skills).

According to teachers' reports provided in the *TIMSS 2011 International Results in Mathematics* report, there was a great deal of variation across countries in the degree of specialization by primary school teachers in mathematics and science education. On average across countries, about half of the fourth grade students were taught mathematics and science by teachers with a major in primary education but not in mathematics or science, and about one-fourth had teachers with a major in primary education and a major in mathematics, science, or both. By comparison, most eighth grade students were taught mathematics by teachers who had a major in mathematics but not in mathematics education (41%), or had a major in both (32%). In science, the majority had teachers with a major in science but not in science education (52%), or who had a major in both (28%). About one-third of the countries reported that teachers have opportunities for professional development, but that it is not mandatory, and in some of these countries, teachers have a recognized right to participate in such voluntary professional development. In the majority of countries, however, some professional development is mandatory and either is integrated into teaching responsibilities or is offered through specific programs or courses, often at institutions of higher education. Professional development requirements varied considerably internationally, from 15–100 hours per year. In several countries, incentives were attached to professional development such as reduced teaching time or increases in salary or rank.

Since 2000, a number of countries also have increased their professional development activities, procedures, and requirements. For example, extensive courses in Armenia have involved more than 4,000 teachers, and other countries have introduced new professional development procedures, such as an entirely new system of training initiatives in the Dutch-speaking community of Belgium, the Universal Teacher Upgrading Project in Indonesia, a campaign in Sweden to improve teacher competence, and a new "comprehensive monitoring" supervision program in Palestine, whereby supervisors have conducted in-service professional development for 100 percent of the teachers. Japan instituted a new professional development system under which all teachers with ten years of experience receive training, and Korea requires teachers with more than three years of service to participate in a 180-hour professional development program during their summer or winter vacations.

Mandatory professional development did not necessarily translate into training related to teaching mathematics or science. Sometimes teachers were required to take specific overarching courses (e.g., counseling or student development), and, even if choices were provided, sometimes professional development in teaching mathematics or science was not an available option. According to teachers' reports (see *TIMSS 2011 International Results in Mathematics* and *TIMSS 2011 International Results in Science*), from 41–46 percent of fourth grade students had teachers who, during the two years prior to the assessment, had taken professional development in mathematics pedagogy, mathematics content, or mathematics curriculum; in addition, from 34–35 percent had teachers who had taken professional development in science pedagogy, science content, or science curriculum. At the eighth grade, there had been somewhat more professional development during the two years prior to the assessment: from 52–58 percent of eighth grade students had teachers with professional development in mathematics pedagogy, mathematics content, or mathematics curriculum; and from 53–58 percent had teachers with professional development in science pedagogy, science content, or science curriculum.

Monitoring Student Progress in Mathematics and Science

In the chapters, countries described a range of school, regional, and national testing practices in primary schools. About one-third of the countries described national assessments or national testing in one or two primary grades (e.g., Grade 3, or Grades 2 and 5) and some of the countries reported giving school-based standardized examinations in the primary grades. All countries reported classroom assessments, and all also mentioned policies and procedures for reporting students' progress to parents.

A range of school, regional, and national testing practices also was reported for students in secondary schools, in addition to more monitoring. For example, many countries described national assessments or national testing in one or all of the middle grades, 5 through 10. For example, in Kazakhstan, beginning in the fifth grade, students are tested at the end of each year to determine promotion to the next grade. Also, even in countries with little or no emphasis on grades in primary school (e.g., Norway), teachers began assigning grades in mathematics and science. In most countries, students and their parents received report cards on a regular basis. Across the countries, teachers conducted a variety of formative assessments based on such techniques as observation, quizzes, checklists, journal writing, and laboratory assignments; and teachers conducted summative assessments based on oral and written examinations, project work, practical work or performance assessments in science, and portfolios.

As found in the reports, *TIMSS 2011 International Results in Mathematics* and *TIMSS 2011 International Results in Science*, internationally, on average, teachers reported that eighth grade students are tested regularly in mathematics—45 percent at least every two weeks and 40 percent about monthly. Only 15 percent were tested less often, approximately a few times a year. Eighth grade students also were tested fairly regularly in science—35 percent at least every two weeks and 41 percent about monthly. Just 24 percent were tested less often, approximately a few times a year.

Nearly all of the countries had an examination system with consequences for students' futures, such as promotion to the next education level, membership in an academic track, or, most commonly, entrance to university. For the most part, countries had mathematics and science examinations with consequences for individual students at the end of secondary school (typically the twelfth grade), although in several countries these were optional depending on students' educational tracks and goals (Exhibits 5 and 6). Many countries also had such mathematics and science examinations at one or more previous grades. There were a number of approaches across the participating countries and slightly fewer had "high stakes" examinations in science than mathematics; however, about half of the countries had examinations with future consequences in both subjects at the end of lower secondary school (typically the ninth grade), and some had examinations with individual consequences at the end of the primary grades (in most cases the sixth grade).

Use and Impact of TIMSS

As reported in their chapters, countries use TIMSS data for system-level monitoring of educational achievement in a global context. Slovenia, for example, uses TIMSS as an important source for changing and improving mathematics and science education. TIMSS participants compare their achievement in mathematics and science and contexts for learning with those of other countries, and monitor progress in educational achievement over time from an international as well as national perspective. Participating countries reported taking advantage of varying amounts of assessment information for evidence-based decision-making, in addition to using other IEA and OECD international assessments as well as national and regional assessments.

Many countries reported initiating educational reforms when TIMSS achievement results were low compared to other countries, or lower than expected (e.g., Bahrain, Macedonia, and South Africa). Also, countries with downward trends in achievement sometimes have implemented new goals and policies to encourage improvement (e.g., the Czech Republic, the Netherlands, and Sweden). Working to achieve equity provided another impetus for reform, and a number of countries report having made special efforts to reduce achievement disparities among ethnic, social, or regional groups (e.g., Australia). Countries implementing educational changes typically look to future TIMSS assessment cycles to monitor improvement.

TIMSS data, frameworks, and released items have been a basis for curriculum reform in almost every country (often in problem solving, reasoning, and inquiry), and for teacher education through teacher education programs, workshops, and websites. Most countries have conducted research using TIMSS data to identify the factors associated with high achievement in mathematics and science, some have very ambitious research programs (e.g., Germany and the Russian Federation), and several regularly encourage dissertations using TIMSS data (e.g., Hong Kong SAR and Iran). TIMSS has informed the content and methods of national assessments (e.g., Armenia, Chile, Ireland, Romania, and Serbia), and several countries report a new emphasis on assessment and evaluation (e.g., Hungary, Italy, Morocco, Qatar, and Thailand).

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Mathematics and Science Curricula and Policies in TIMSS 2011 Countries

Results from the Curriculum Questionnaire

Exhibit 1: National/Regional Policies to Involve Parents in School Management

Reported by National Research Coordinators

Country	Description of Policy
Armenia	Parents can be included in school governing bodies.
Australia	Varies by state but, in general, there is a mandated parent position on school-governing bodies. Other forms of parental involvement, possibly included in official policy, include the following: parents' clubs (for support and advocacy); Parent-Teacher Evenings (to discuss student progress); and volunteering within the school (e.g. to assist in class, on excursions, and in support functions like the cafeteria).
Austria	A class forum must be held at least once a year, to elect a class parental representative and determine classroom level decisions. The class parental representative also represents class interests at the school forum. Principals must support the establishment of parental communities, and the curriculum specifies that close contact between parents and school is necessary to effectively promote children.
Azerbaijan	No specific policy, but the vast majority of schools have parent committees that seriously affect school activities and work closely with governmental educational institutions.
Bahrain	There is a Parental Council for each school with regular meetings arranged by the school.
Belgium (Flemish)	Each school has an advisory committee that includes elected parents.
Botswana	Per government policy, the community should be as involved as possible in the development and management of education.
Chile	Municipal and subsidized schools are required to have a School Council. A parent representative is part of this council, which has an advisory role on general principles of the school such as the school goals, extra-curricular activities, and disciplinary issues. The administrator of the school also may give the council the authority to decide on certain school affairs. Schools also have a Parent Council elected by the parents of students at the school. Additionally, the Ministry sends a report with the school's results on the national assessment tests (Simce) to the parents each year. It also gives them information such as the school's administrative characteristics, cost, trends in the Simce results, and the student's results on the University entrance test together with a map of the other schools that are located in the area.
Chinese Taipei	The Educational Fundamental Act regulates parental involvement in school affairs during the period of compulsory education. The main policies include the following: parents, parent groups, and parent committees have the right to participate in educational affairs in schools; parents must take good care of their own children and actively work with schools to improve children's growth and learning; parents have the responsibility to participate in school and classroom activities; schools must set up Parent Teacher Associations (PTA), and all parents have the right to be involved; schools must publically inform parents of school regulations, content, methods of instruction, and assessment criteria; and schools should schedule a parent-teacher interview within one week before to three weeks after the beginning of the semester.
Croatia	Each class has one parent representative, who is included in the school governing body.
Czech Republic	Parents participate in school management through participation in a School Council.
Denmark	Cooperation between parents and schools is required by law. Students and parents are to be informed twice a year about student academic achievement, as well as the student's social and personal development. All schools must have a School Board with a majority of parent members elected by the parents of all students at the school. The School Board establishes all general principles for the school, including school-home cooperation.
England	Schools are required to have two parent governors on their governing bodies. Schools typically go to great lengths to encourage parental engagement.
Finland	By law, schools must communicate and cooperate with parents. Parents should be informed about student work, progress, and behavior frequently. The national framework curriculum emphasizes shared parent/school responsibility for student upbringing (primary responsibility of parents) and education (primary responsibility of school). In practice, schools may organize parents' evenings and, especially in Grades 1–6, assessment discussions together with individual teachers, parents, and students.
Georgia	According to the law on general education, parents must be members of school boards in Georgia. They are elected for 3 years. The number of parents involved in school boards is regulated by the school charter.
Germany	Parental involvement is regulated by the state constitution and the school's policy, with the latter falling under the state's supreme authority. According to the Basic Law, the care and upbringing of children are a right and duty primarily incumbent on parents, although the state oversees the exercise of parental rights. While the state is fundamentally responsible for the schooling of children, the state's right to regulate the education of children at school is limited by parental rights to raise their children. At the school and classroom level, the states are free to equip parent councils with rights of participation, although approaches vary by state, and parents generally exercise their rights, individually or collectively, through parent groups and their representatives on other consulting and decision-making bodies at schools. Parent representatives at the school level are most often involved in organizing school life, student protection, and organizing events outside, though under the supervision, of school. Parents also may be involved with general education and teaching questions, school organization, discipline, parent counseling, and head teacher selection.
Ghana	All parents are members of Parent-Teacher Associations and a few of them are in the School Management Committees, which manage schools at the local level.
Honduras	As of 2011, parents and civil society organizations must be included in school governing bodies at the local and regional levels.
Hong Kong SAR	Almost every school has a Parent Teacher Association. For a school with an Incorporated Management Committee (IMC), parent representatives are nominated to serve as parent managers of the governing body.
Hungary	Schools must set up a parental team, which has the right to give its opinion on various issues.
Indonesia	No policy
Iran, Islamic Rep. of	Parent-School Associations are required to meet during the school year to discuss school management policies and to discuss parents' perspectives regarding their children's education.

A dash (–) indicates data not provided.

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 1: National/Regional Policies to Involve Parents in School Management (Continued)

Country	Description of Policy
Ireland	The Education Act requires all schools to encourage parental involvement in the education of students and in the achievement of school objectives. All schools are required to support the establishment of a Parents Association, whose role is to adopt a program of activities promoting parental involvement in the operation of the school. Schools are expected to develop a clearly defined policy for parental involvement and to share information with parents on all aspects of learner progress and development. Schools with a socio-economically disadvantaged enrollment can access a Home/School/Community/Liaison Scheme (HSCL), a preventative strategy targeting students at risk of not reaching their potential that establishes a partnership and collaboration between parents and teachers in the interests of children's learning. Objectives specified in the July 2011 National Literacy and Numeracy Strategy require most schools to increase current levels of support for, and communication with, parents.
Israel	No comprehensive policy. However, 10 years ago a national center for the promotion and development of parent-teacher relations was established within the Ministry of Education. The framework of this center was adopted by 30% of schools. Parents can be included in school bodies and are welcome to participate, though only in a volunteer capacity. They are also welcome to participate and be involved in their children's studies and achievements through special internet sites, where they can follow their children's pedagogical data.
Italy	In each school, there are parent representatives on the school and class governing boards. Teachers are available to meet parents at school to provide updates on children's progress throughout the school year.
Japan	Public elementary schools are established and administered by the local Board of Education, which must include at least one parent member. Through the School Management Council System, schools are expected to gain the understanding and participation of parents and local residents, and to promote school development through coordination and cooperation with schools, households, and the local community.
Jordan	Parents must be included and represented on the Teacher Parent Council.
Kazakhstan	In each school, parents must be included in a parental committee and participate in public school life. Active parents are recognized through letters of appreciation.
Korea, Rep. of	There are school steering committees and Parent Teacher Associations.
Kuwait	With headmaster approval, parents can participate in the Parents' Council, which is involved in some school activities but not in the school's educational policy. Parents' proposals are studied and submitted to the relevant authorities for consideration.
Lebanon	–
Lithuania	Parents usually participate in a school council. There also is a national parent organization that participates in discussions related to important documents regulating the education process.
Macedonia, Rep. of	Parents are included in different parts of the teaching process (e.g., parents are members of the school board).
Malaysia	No policy
Malta	All State Schools have School Councils made up of eight members: the Council President (who is nominated by the Ministry of Education), the Council Secretary/Treasurer (the Head of School), and three teachers' and three parents' representatives who are elected for two-year terms by the school and the parents. Guidelines are in place regarding the role and duties of School Councils. Each school is required to hold one Parents' Evening and one Parents' Day during each school year when children's progress is discussed.
Morocco	The Charter for Education and Training stipulates that parents shall be involved in their children's educational affairs. Parents are present in at least two important school councils, parent associations, and school management council. Parents guarantee openness to the school environment, contribute to parent awareness-raising, establish bidirectional cooperation, help combat student absenteeism and encourage retention, and contribute to the establishment of improvement plans based on student results.
Netherlands	By law, schools should provide parents the opportunity to help with all kinds of school tasks, and to take part in a school's Participation Council.
New Zealand	Parent representation on school governing boards is mandatory. Parents are actively encouraged to be involved in their child's learning. All schools are required to provide feedback to parents on their children's achievement. Primary schools must give parents written reports twice a year on their children's progress in relation to the national standards for literacy and mathematics.
Northern Ireland	"Every School a Good School - a policy for school improvement" sets out the Department of Education's overarching approach to raising standards. One of the policy's priorities is promoting greater parental involvement and engagement in their child's education. Schools are required to provide parents with regular updates on their child's progress, including an annual report. The Extended Schools program supports schools serving disadvantaged communities in encouraging and supporting greater parental involvement by enabling them to provide services for students and parents. These might include parenting classes or literacy, numeracy, and homework support classes for parents. Parent governors form part of every school's Board of Governors. By legal requirement, these governors are formally elected by the parents of students attending the school. Many schools also have Parent Teacher Associations (PTA), which bring together parents and teachers to encourage greater involvement of parents in the life of the school. Many PTAs also carry out fundraising activities on behalf of the school.
Norway	At the national level, there is a National Parents' Committee for Primary and Secondary Education based in Oslo for parents who have children in primary and/or secondary education. At the local level, all parents who have a child at a school are members of the school's parents' council. The parents' council elects a working committee, which represents the voice of the parents with respect to the school. The working committee is responsible for ensuring that parents have a real influence and also is jointly responsible for ensuring that the students' learning environment is secure and good.
Oman	Parents' councils are set at each school, members of which are elected by the school and the parents. There are special guidelines regarding the role and duties of the council. Regional parent committees also are formed by the Wali of each region, where the heads of the parents council at schools serve as members on this committee. This committee discusses broader issues and makes decisions accordingly.
Palestinian Nat'l Auth.	All schools have a parents' council.

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 1: National/Regional Policies to Involve Parents in School Management (Continued)

Country	Description of Policy
Poland	A school is obliged to have a parent committee.
Portugal	Parents must be included in school governing bodies, and local parent associations are invited to participate in school decisions and activities.
Qatar	The Supreme Education Council seeks to encourage the role of the community in independent schools through boards of trustees. These boards link the community and the schools and are responsible for ensuring the quality of education provided in the schools. All members of boards of trustees perform their functions voluntarily, representing the interests of parents and the school community. Their roles are simultaneously supervisory and fiscal.
Romania	A parent is on each school's administration council. Parents also are involved in the choice of optional subjects. As of 2012, parents will make up one-third of council of administration membership.
Russian Federation	Parents participate in the school supervisory board.
Saudi Arabia	Parents can join the school administration council, where they attend meetings and discuss issues related to student needs.
Serbia	Parents must be included in the work of the school, including the following: Parents' Council, the school advisory body, the school board, the governing body, and school evaluation. Schools may have individual initiatives that include parents in the school program, development plan, and annual school calendar.
Singapore	Schools are encouraged to engage parents and the community as partners in education. Schools tailor specific parent outreach programs to engage parents in their children's education (e.g., formation of Parent Support Groups and providing student performance reports).
Slovak Republic	Every school must have a School Board that includes parents and other local community representatives. The School Board is mainly responsible for electing of the school headmaster and monitoring the conceptual objectives of the school progress. Though not obligatory, most schools also establish Parents Boards, constituted by parent representatives from particular grades. A few times per year, parents generally are asked to meet with teachers and discuss academic progress, student behavior, and organizational issues.
Slovenia	Parents must be included in school governing bodies, informed about student achievement by the school, and are expected to regularly participate in meetings with class teachers. Parents are invited to participate at school celebrations prepared by students, and are asked permission for all activities in which their child is included yet which are not considered formal schooling.
South Africa	Parents are elected to participate in school governing bodies, and many schools also have parent-teacher associations.
Spain	Parent representatives must be included in the school governing council, together with student representatives, teacher representatives, the principal, and a member of the local council.
Sweden	The curriculum states that parents and schools have the responsibility to create the best possible conditions for the development and learning of children and young persons. The guidelines state that all who work in the school should work together with parents to develop both the content and the activity of the school. Teachers should work together with parents and continuously provide them with information concerning their student's school situation, well-being, and acquisition of knowledge. Teachers also should stay informed about individual students' personal situations and, in doing so, show respect for student integrity. The responsibility lies with the school and not with the parents.
Syrian Arab Republic	Parents are not involved in school governing bodies, but they are involved in evaluating the new curricula and discussing issues with teachers and the administration. The ministry is currently trying to develop this relationship between the school and parents.
Thailand	Schools should establish a teacher-parent group to help the school administration in activities such as fund raising and academic support.
Tunisia	No policy
Turkey	Parents can be included in school-family bodies.
Ukraine	There are regular parental meetings in each class, while groups of parents also take part in school educational policies.
United Arab Emirates	Parent Councils at the school and educational zones levels give parents the opportunity to be involved in some educational decisions regarding their children's learning. Parents also are allowed to participate in school events such as open day, camps, trips, competitions, and cultural and community activities.
United States	Encouraging parent involvement in elementary schools is widespread. The No Child Left Behind Act recognizes the role of parents in improving student outcomes and includes among its purposes, "affording parents substantial and meaningful opportunities to participate in the education of their children." For example, there are specific provisions to support Parental Assistance and Local Family Information Centers, which are intended to promote parental involvement toward higher student achievement. Many federal programs also encourage parental participation, but these programs do not apply to all schools and students. Most, if not all, schools welcome and encourage parent participation in both routine and special activities, and have volunteer programs often coordinated by parent/teacher associations.
Yemen	There is an official by-law for Fathers and Mothers Councils (FMCs). Their primary role is to support the school rather than to govern.

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 1: National/Regional Policies to Involve Parents in School Management (Continued)

Country	Description of Policy
Benchmarking Participants—Responses Pertain to Benchmarking Provinces/Emirates/States	
Alberta, Canada	The School Act states that parents have a right and responsibility to make decisions respecting the education of their children. Public schools, including charter schools, are required to establish school councils, each of which must include the school principal, teacher(s), parents of students enrolled in the school, in addition to student(s) (at the secondary level only).
Ontario, Canada	All district school boards have Parent Involvement Committees, and each school has an advisory school council through which parents and other school community members can contribute to improving student achievement and school performance.
Quebec, Canada	By law, a minimum of four parents must be on the Establishment Council. In addition, school boards have some parent committees.
Abu Dhabi, UAE	All schools have an advisory Parent Council that provides a vehicle for participation.
Dubai, UAE	Public schools follow UAE regulations. Private school policies vary by school type.
Alabama, US	Alabama adopted the national standard for parental involvement.
California, US	The State Board of Education continues to support assistance to school districts and schools in developing strong comprehensive parent involvement. Parents are involved at all grade levels in a variety of roles. The efforts should be designed to do the following: help parents develop parenting skills to meet the basic obligations of family life and foster conditions at home which emphasize the importance of education and learning; promote two way (school-to-home and home-to-school) communication about school programs and students' progress; involve parents in instructional and support roles at the school and in other locations that help the school and students reach stated goals, objectives, and standards; provide parents with strategies and techniques for assisting their children with learning activities at home that support and extend the school's instructional program; prepare parents to actively participate in school decision making and develop their leadership skills in governance and advocacy; and provide parents with skills to access community and support services that strengthen school programs, family practices, and student learning and development.
Colorado, US	No policy
Connecticut, US	State law requires that local boards of education have written policies and procedures to encourage parent-teacher communication. These policies and procedures vary but may include monthly newsletters, required regular contact with all parents, flexible parent-teacher conferences, drop-in hours for parents, home visits and the use of technology such as homework hot lines to allow parents to check on their children's assignments and students to get assistance if needed.
Florida, US	Parents must be members of the school advisory council, which assists in the preparation and evaluation of the school improvement plan. School districts must provide parents specific information about their child's educational progress, and choices and opportunities for involvement in their child's education, as well as provide a framework for building and strengthening partnerships among parents, teachers, principals, district school superintendents and other personnel. Each year, school districts must submit the following to the Department of Education: a copy of their school board rules on parent involvement, a hard copy of the parent guide, a copy of the parent checklist, and copies of report cards that document a student's performance or non-performance at grade level.
Indiana, US	Local schools are encouraged to involve parents. Each school may develop a written compact that contains the expectations for parental involvement. Parental involvement is encouraged in discipline procedures or practices. Also, superintendents can involve parents on committees for local textbook adoption.
Massachusetts, US	No policy
Minnesota, US	The department, in consultation with the state curriculum advisory committee, must develop guidelines and model plans for parental involvement programs. Activities contained in the model plans include the following: educational opportunities for families; educational programs on families' educational responsibilities and resources; the hiring, training, and use of parental involvement liaison workers to communicate among families, educators, and students; home and community-based learning activities that reinforce and extend classroom instruction; technical assistance, including training to design and carry out family involvement programs; parent resource centers; parent training programs; reports to parents on children's progress; use of parents as classroom volunteers; soliciting parents' suggestions in planning, developing, and implementing school programs; educational programs and opportunities for parents or guardians that are multicultural, gender fair, and disability sensitive; and involvement in a district's curriculum advisory committee or a school building team.
North Carolina, US	Local school districts and school personnel will encourage and involve parents by providing various opportunities for involvement such as establishing programs and practices that enhance parent involvement and that reflect the specific needs of students and their families, as fully described in Family/Parent Involvement Policy FCB-A-000.

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 2: Years of Compulsory Schooling*

Reported by National Research Coordinators

Country	Ages and/or Grades of Compulsory Schooling		Grades Provided for Primary and Secondary Schooling (Not Including Preprimary)
	Ages	Grades	
Armenia	n/a	1–9	1–12
Australia	6–16	1–10	1–12
Austria	6–15	1–9	1–12 or 13
Azerbaijan	6–17	1–11	1–11
Bahrain	6–15	1–9	1–12
Belgium (Flemish)	6–18	1–12	1–12
Botswana	Not compulsory	Not compulsory	1–12
Chile	6–18	1–12	1–12
Chinese Taipei	6–15	1–9	1–12
Croatia	6 or 7–13 or 14	1–8	1–12
Czech Republic	6–15	1–9	1–12 or 13
Denmark	6–16	0–9	1–12 or 13
England	5–16	K–10	1–10
Finland	7–16	1–9	1–12
Georgia	6–15	1–9	1–12
Germany	Varies by state (6–18)	Varies by state (full-time Grades 1–9 or 10)	1–12 or 13
Ghana	n/a	1–9	1–12
Honduras	7–12	n/a	1–12
Hong Kong SAR	6–15	1–9	1–12
Hungary	6–18	1–12	1–12 or 13
Indonesia	7–16	1–9	1–12
Iran, Islamic Rep. of	6–15	1–9	1–12
Ireland	6–16	n/a	1–12
Israel	5–16	n/a	1–12
Italy	6–16	1–10	1–13
Japan	6–15	1–9	1–12
Jordan	6–16	1–10	1–12
Kazakhstan	6–17	1–11	1–11
Korea, Rep. of	6–14	1–9	1–12
Kuwait	6–17	1–9	1–12
Lebanon	6–16	1–9	1–12
Lithuania	7–16	n/a	1–12
Macedonia, Rep. of	6–18	1–12	1–12
Malaysia	6–17	1–11	1–11
Malta	5–16	1–11	1–11
Morocco	6–15	1–9	1–12
Netherlands	5–18 (or 16 with a diploma)	n/a	1–12
New Zealand	6–16	n/a	Years 1–13
Northern Ireland	4–16	1–12	1–14
Norway	6–16	1–10	1–13
Oman	Not compulsory	Not compulsory	1–12
Palestinian Nat'l Auth.	5 years, 9 months–16	1–10	1–12
Poland	7–18	1–9	1–11, 12, or 13
Portugal	6–18	1–12	1–12
Qatar	6–15	1–9	1–12
Romania	n/a	1–10	1–12
Russian Federation	6.5–18	1–11	1–11
Saudi Arabia	6–18	1–12	1–12
Serbia	6.5 or 7.5–15	n/a	1–12
Singapore	n/a	1–6	1–10
Slovak Republic	6–16	n/a	1–13
Slovenia	6–15	1–9	1–12 or 13
South Africa	7–15	1–9	1–12
Spain	6–16	1–10	1–12
Sweden	7–16	1–9	1–12
Syrian Arab Republic	6–14	1–9	1–12
Thailand	7–15	1–9	1–12
Tunisia	6–16	1–9	1–13
Turkey	6–14	1–8	1–12
Ukraine	6–17	1–11	1–11
United Arab Emirates	5.5–16	1–9	1–12
United States	Varies by state	Varies by state	1–12
Yemen	n/a	1–9	1–12

*For policies on preprimary education see Exhibit 4.

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

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

Exhibit 2: Years of Compulsory Schooling* (Continued)

Country	Ages and/or Grades of Compulsory Schooling		Grades Provided for Primary and Secondary Schooling (Not Including Preprimary)
	Ages	Grades	
Benchmarking Participants—Responses Pertain to Benchmarking Provinces/Emirates/States			
Alberta, Canada	6–16	Typically 1–10	1–12
Ontario, Canada	6–18	n/a	1–12
Quebec, Canada	6–16	n/a	1–11
Abu Dhabi, UAE	6–16	n/a	1–12
Dubai, UAE	n/a	1–9	1–12
Alabama, US	7–17	n/a	1–12
California, US	6–18	n/a	1–12
Colorado, US	6–16	n/a	1–12
Connecticut, US	7–17	n/a	1–12
Florida, US	6–16	n/a	1–12
Indiana, US	7–18	n/a	1–12
Massachusetts, US	6–16	n/a	1–12
Minnesota, US	7–16	n/a	1–12
North Carolina, US	7–16	n/a	1–12

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 3: National Policies on School Entry and Promotion

Reported by National Research Coordinators

Country	Official Policy on Age of Entry to Primary School	Based on Parental Discretion, Usual Practice on Age of Entry to Primary School	Age of Entry Policy has Changed Within Past 10 Years	Policy on Promotion and Retention in Grades 1–8
Armenia	Children must be 6 years old to begin the following December 31st.	n/a	●	Automatic promotion for Grades 1–5, dependent on academic progress for Grades 6–8.
Australia	Varies by state, but generally children must begin school by age 6.	Most children begin school at the minimum age of 4.5–5 years but some wait until the compulsory age, either on advice from preschool staff or on the judgment of parents, usually because of maturity.	●	Varies by state; generally, automatic promotion for Grades 1–8.
Austria	Children must begin school on the September 1st following their 6th birthday.	Parents can request early admission for children who turn 6 years old by March 1st of the following calendar year, provided that they are mature for schooling and have the required social competence for attending school.	○	Automatic promotion for Grade 1; retention in Grades 2–4 for students failing one or more compulsory subjects.
Azerbaijan	Children must begin school at age 6. Children must be 6 years old by the end of September to begin school on September 15 of the same year.	Children born before the end of November the year they turn 6 who are identified as talented by the Ministry of Education testing commission can begin school on September 15 of the same year.	○	Automatic promotion for Grades 1–4, dependent on academic progress for Grades 5–8.
Bahrain	The official policy states that parents must register their children at school when they are 7 years old. Children must be 6 years old by the end of June to begin the following September.	n/a	●	Promotion dependent upon passing Arabic, Mathematics, Science, and English.
Belgium (Flemish)	Children must begin September 1st of the year of their 6th birthday.	Parents can keep their child in kindergarten until age 7, with approval.	○	Promotion decided by each school and/or parents; students not having fully attended preprimary education must pass language qualification test to begin primary school.
Botswana	Children must be 6 years old by the end of June to begin in January of the same calendar year.	Even though the official policy is that children begin school in the year they turn 6, children from remote areas may begin later than age 6.	○	Up to 12.5% retention in each class; accelerated progression after parent consultation.
Chile	Compulsory schooling begins at age 6. Children must be 6 years old by March 31st to begin in March of the same calendar year.	n/a	○	Promotion dependent on academic progress for all grades.
Chinese Taipei	Compulsory schooling begins at age 6. Children must be 6 years old before September 1st to begin in September of the same calendar year.	n/a	○	Automatic promotion for Grades 1–8.
Croatia	All children must begin school by 7 years old. Children must be at least 6 years old by the end of March to begin the following September.	Children typically begin school at age 7 because their parents feel they will benefit from being more mature.	●	Students in Grades 1–3 must obtain minimum standards in most subjects; students in Grades 4–8 must obtain all minimum standards for promotion to next grade.
Czech Republic	Compulsory schooling begins at the beginning of the school year (September 1st) following the child's 6th birthday, unless granted a postponement.	Children's maturity is assessed during their enrollment to school. If a child is not considered mature enough to attend school, he/she continues to attend either a nursery school or a preparatory class. In rare cases, a child younger than 6 years old may be admitted to compulsory school. However, a gradually increasing number of parents (about 20%) are choosing to postpone the beginning of school attendance for their children.	○	Promotion dependent on academic progress in all compulsory subjects; automatic promotion for students having repeated a year.
Denmark	Children begin preprimary education the year they turn 6. Primary education begins the following year.	The municipal board must approve parental requests to delay one year, but parents can elect to begin children one year earlier.	●	Automatic promotion; in special cases, students may be promoted or retained based on individual assessments, with parental consent.

● Yes
○ No

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 3: National Policies on School Entry and Promotion (Continued)

Country	Official Policy on Age of Entry to Primary School	Based on Parental Discretion, Usual Practice on Age of Entry to Primary School	Age of Entry Policy has Changed Within Past 10 Years	Policy on Promotion and Retention in Grades 1–8
England	Children begin the term (typically September, January, or April) of their 5th birthday.	Some local authorities maintain two points of entry, typically September and January, and many make provision for all children to begin in September of the school year in which they will turn 5. Some local authorities have changed the discretionary time so that children can begin at a younger age. All of this is subject to parental discretion.	○	No policy
Finland	Children begin the autumn of the year of their 7th birthday.	It is possible to enter school either one year earlier or one year later than the official policy. This is usually initiated by the parents or preprimary teachers if there are concerns about the child's maturity for school, and discussions with an expert (e.g., school psychologist) are required.	○	Automatic promotion for Grades 1–8; retention only in extreme situations.
Georgia	Compulsory schooling begins at age 6. According to the Law on General Education, children can begin the calendar year of their 6th birthday.	n/a	●	Automatic promotion for Grades 1–4, dependent on academic progress for Grades 5–8.
Germany	Compulsory schooling begins the year a child turns 6. Children must be at least 6 years old before a statutory qualifying date (which varies by state; in most states the date falls between June 30th and September 30th) to begin on August 1st.	Official policy grants the right to parents to request early admission or postponed enrollment, but the school administration has the final decision.	●	Automatic promotion in Grade 1; promotion policies differ between states for later grades.
Ghana	Children begin the calendar year of their 6th birthday.	n/a	○	Automatic promotion in Grades 1–6, dependent on academic progress for Grades 7–9. Mostly automatic promotion in public schools.
Honduras	Compulsory schooling begins at age 7. Children must be 7 years old by the end of January to begin the following February.	About 30% of children typically begin primary school at age 6, per principals' decisions.	○	Dependent on academic progress on exams prepared and administered by teachers.
Hong Kong SAR	Children begin the September after they turn 5 years, 8 months old.	n/a	○	Representatives of Education Bureau may prescribe maximum rate of repetition.
Hungary	Children begin school during the calendar year they turn 6 if their birthday is before May 31st.	Per parental request, children may begin during the calendar year of their 6th, 7th, or 8th birthday.	○	Automatic promotion in Grades 1–3, dependent on academic progress for Grades 4–8.
Indonesia	Children must be 7 years old by the end of June to begin on July 12th.	Parents have some choice in starting children at age 6.	○	Promotion dependent on academic progress for Grades 1–8.
Iran, Islamic Rep. of	Children must be 6 years old by September 22nd to begin September 23rd.	Few private schools allow registration at 6.5 years.	○	Students with failing grades in June must take cumulative exam in September to determine promotion or retention.
Ireland	The Education (Welfare) Act of 2000 requires children to attend primary school from the time that they are 6 years old but not before they are 4.	In practice, nearly half of 4-year-olds and almost all 5-year-olds are enrolled in infant classes in primary schools.	○	Children only allowed to repeat a year for educational reasons and in exceptional circumstances.
Israel	Children begin the calendar year of their 6th birthday.	Parents have final say if they feel their children are not ready to begin school.	○	Retention only in exceptional cases.
Italy	Children begin the calendar year of their 6th birthday.	If a child will turn 6 years old by April 30th of the following calendar year, parents may enroll the child in the calendar year of their 5th birthday.	●	Dependent on academic progress for Grades 1–8.
Japan	Compulsory schooling begins at age 6. Children must be 6 years old by April 1st.	n/a	○	No policy

● Yes
○ No

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 3: National Policies on School Entry and Promotion (Continued)

Country	Official Policy on Age of Entry to Primary School	Based on Parental Discretion, Usual Practice on Age of Entry to Primary School	Age of Entry Policy has Changed Within Past 10 Years	Policy on Promotion and Retention in Grades 1–8
Jordan	Compulsory schooling begins at 6 years old. Children must be at least 5 years, 8 months old by September 1st to begin school.	n/a	○	Dependent on academic progress in Arabic and Mathematics for Grades 1–3, with parental consent; dependent on academic progress for Grades 4–8. Students should not repeat a grade more than twice.
Kazakhstan	According to the Law of Education (2007), children must begin at age 6.	Parents can postpone enrollment for one year.	●	Dependent on academic progress for Grades 1–4, dependent on successfully passing exams for Grades 5–8.
Korea, Rep. of	Children begin school during the calendar year of their 6th birthday. Children must be 6 years old by the end of December to begin school in March of that year.	Parents can decide to send their children a year later (at age 7) due to health reasons or a year early (at age 5).	●	Dependent on academic progress and attendance for Grades 1–8.
Kuwait	Children must be 6 years old by March 15th to begin school that calendar year.	Children typically begin primary school at age 5.5 or 6; policy does not allow for parental discretion.	○	Automatic promotion for Grades 1–3, dependent on academic progress for Grades 4–8.
Lebanon	Children must be 6 years old by the end of June to begin school the following September.	There is no opportunity for parental discretion in private schools. In public schools, special cases may be authorized by the Ministry of Education.	○	Automatic promotion for Grades 1–6, dependent on academic progress for Grades 7–8.
Lithuania	Children must begin in the calendar year of their 7th birthday.	Parents can enroll children 1 year early if the child satisfies the requirements of the Ministry of Education and Science.	●	No national policy, decisions made at school level.
Macedonia, Rep. of	Since 2007, children must be 6 years old by the end of December to begin school the following September. Before 2007, children had to be 6 years old by the end of May to begin school the following September.	n/a	●	Automatic promotion for Grades 1–5, dependent on academic progress for Grades 6–8.
Malaysia	Children begin at the beginning of January of the calendar year of their 6th birthday.	n/a	○	No policy
Malta	Children begin in late September of the calendar year of their 5th birthday.	n/a	○	At the primary level, students repeat a class only in exceptional circumstances and after consultation between head of school, teacher, and parents. At the secondary level, students may repeat a year on the basis of their academic performance and other factors in exceptional circumstances. Grade retention can be resorted to only once during each education cycle.
Morocco	Children must be at least 5 years and 6 months old by the beginning of September.	Parents rarely postpone the start of school for their children.	○	Promotion depends on academic progress for both primary and secondary grades. Promotion in primary school exceeds 90%.
Netherlands	Children must begin kindergarten on the first school day of the month after their fifth birthday.	Most children begin kindergarten when they turn 4. Most children are 6 years old when they enter primary education. Some children begin primary education a year later (7 years old) because teacher and parents agree that their child would benefit from being more mature.	○	Promotion and retention decided by the school, dependent on academic progress.
New Zealand	Children must be enrolled by their 6th birthday but have the right to begin school at age 5.	Nearly all children begin school on or soon after their 5th birthday.	○	Automatic promotion; retention only in very special circumstances, with both school and parents involved in making the decision.
Northern Ireland	Compulsory schooling begins at age 4. Children must be 4 years old by July 1st to begin in September.	n/a	○	The majority of children begin and continue class with their age group, but some transfer to post-primary a year late or early.
Norway	Children must begin the calendar year of their 6th birthday.	n/a	○	Automatic promotion for all grades.

● Yes
○ No

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 3: National Policies on School Entry and Promotion (Continued)

Country	Official Policy on Age of Entry to Primary School	Based on Parental Discretion, Usual Practice on Age of Entry to Primary School	Age of Entry Policy has Changed Within Past 10 Years	Policy on Promotion and Retention in Grades 1–8
Oman	Children begin the year of their 6th birthday. Children must be at least 5 years, 9 months old at the start of the academic year (beginning of September).	Parents can enroll their children in private schools where official entry age is 5 years, 5 months.	●	Automatic promotion for Grades 1–4, dependent on academic progress for Grades 5–8.
Palestinian Nat'l Auth.	Children must be 5 years, 9 months old by the beginning of the September in which they enroll.	Parents can enroll children in private schools two months earlier than public schools.	○	Automatic promotion for Grades 1–3, dependent on academic progress for Grades 4–8. A maximum of 5% of students in each class may be retained.
Poland	Children must begin the calendar year of their 7th birthday.	Parents can postpone the beginning of school for medical or psychological reasons.	●	Parental consent required for retention in Grades 1–6, dependent upon academic progress in higher grades.
Portugal	Children must begin the year of their 6th birthday if they turn 6 years old by September 15th.	Parents can enroll children who turn 6 years old by the end of December, dependent on school availability. In rare situations, children with an exceptional level of development can begin at 5 years old.	●	Automatic promotion for Grade 1, dependent on academic progress for Grades 2–8.
Qatar	Children must begin school in September of the calendar year of their 6th birthday.	Parents can enroll their children in private schools where official entry age is 5 years, 5 months.	○	Promotion is dependent on academic progress for Grades 1–8.
Romania	According to the law of education, children must begin school at age 6.	Parents can postpone enrollment for one year.	●	Automatic promotion for Grade 1, dependent on academic progress for Grades 2–8.
Russian Federation	Children must be at least 6 years, 6 months old by the end of August to begin in September.	Children typically begin at age 7 because their parents feel they will benefit from being more mature.	○	Promotion is automatic for Grade 1 and dependent on academic progress for Grades 2–8.
Saudi Arabia	Children must begin the calendar year of their 6th birthday.	n/a	○	No policy
Serbia	Children must begin by the time they are 7.5 years old. Children begin school in September when they are at least 6.5 years old.	Schools may recommend one year of continued preparatory preschool for children not considered school ready.	●	Automatic promotion for Grade 1, generally automatic for Grades 2–3, except per parent request; in Grades 4–7, students failing 2 or more subjects must pass makeup exams.
Singapore	According to the Compulsory Education Act, children must begin school the calendar year of their 7th birthday.	Parents may seek a deferral of registration based on medical grounds.	○	Automatic promotion for Grades 1–4, retention at principal's discretion for Grade 5 and dependent on academic progress for Grades 6–8.
Slovak Republic	Children must begin in September if they turn 6 years old by August 31st.	Children may begin school early or after an approved delay, based on psychological tests and professional recommendations.	○	Promotion dependent on academic progress. Students failing 1–2 required subjects must pass makeup exam; students failing more than 2 are retained.
Slovenia	Children must begin the calendar year of their 6th birthday.	In some cases, children who are 6 years old in January enter school in September of the calendar year before they turn 6.	●	Generally automatic promotion for Grades 1–8, except students with learning difficulties.
South Africa	Compulsory schooling begins at age 7. Children must be 6 years old by June 30th of the year in which they enroll.	Children are encouraged to begin at age 7 because schools and parents feel that they will benefit from being more mature.	●	Automatic promotion in all grades; for retention, an application has to be made to the provincial authorities for permission. Students may only be retained once within a phase of about 3 years.
Spain	Children must begin the calendar year of their 6th birthday.	Almost every child begins kindergarten at the age of 3 even though it is not compulsory.	○	Students can be retained for 1 year during Grades 1–6, but students with special needs can be retained twice. Students that do not reach the goals in Grades 7 and 8 can be retained in both grades.
Sweden	Children begin in the fall of the calendar year of their 7th birthday.	Children can begin the year they turn 6 or 8 years old for special reasons.	○	Automatic promotion for all grades.

● Yes
○ No

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 3: National Policies on School Entry and Promotion (Continued)

Country	Official Policy on Age of Entry to Primary School	Based on Parental Discretion, Usual Practice on Age of Entry to Primary School	Age of Entry Policy has Changed Within Past 10 Years	Policy on Promotion and Retention in Grades 1–8
Syrian Arab Republic	Children must begin the September following their 6th birthday.	n/a	○	Based on academic promotion for Grades 1–8. There is automatic promotion when a student fails a grade for the second time.
Thailand	Children must begin the year of their 7th birthday, but can begin when they turn 6.	n/a	○	No policy
Tunisia	Children begin in September of the calendar year of their 6th birthday.	Younger children are accepted if there are school vacancies in the area where they live.	○	Dependent on academic progress in Arabic, French, Mathematics, and Science for Grades 1–6; dependent on academic progress for Grades 7–8.
Turkey	Children begin in September of the calendar year of their 6th birthday.	Children can begin a year later, at parental discretion.	○	Automatic promotion for Grades 1–3, dependent on academic progress for Grades 4–8.
Ukraine	Compulsory schooling begins at age 6. Children must be at least 6 years old by September 1st.	Parents can decide if children begin school at age 6 or 7.	○	Retention decided by parents; students can take external examinations to advance into higher grade levels.
United Arab Emirates	Children can begin when they are 5.5 years old, but must begin by age 8.	Parents or guardians can decide when children begin school, but it must by age 8.	●	Students in Grades 1–5 who have not achieved 50% or more of the subjects grade must receive remedial instruction to be promoted. Promotion in Grades 6–8 dependent on academic achievement.
United States	Varies by state	Children typically begin kindergarten at age 5.	○	Varies by state
Yemen	Children can begin the year of their 6th birthday.	Some flexibility exists at the discretion of the school's director.	○	Automatic promotion for Grades 1–3, dependent on academic progress for Grades 4–8.

● Yes
○ No

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 3: National Policies on School Entry and Promotion (Continued)

Country	Official Policy on Age of Entry to Primary School	Based on Parental Discretion, Usual Practice on Age of Entry to Primary School	Age of Entry Policy has Changed Within Past 10 Years	Policy on Promotion and Retention in Grades 1–8
Benchmarking Participants—Responses Pertain to Benchmarking Provinces/Emirates/States				
Alberta, Canada	The law requires all children who are 6 by September 1 to attend school. However, school boards may set their own age requirements for entering school. Many boards allow children to enter Grade 1 if they are six years old by March 1 of the following year.	Parental discretion or choice is allowed. Kindergarten is a voluntary program intended for children in the year prior to entering Grade 1.	○	School principal makes promotion decisions in line with school policies.
Ontario, Canada	Children must attend school in September if they turn 6 years old by September 1. However, they have the right to attend school in September if they will turn 6 by December 31 of that calendar year.	Parents may enroll their children in junior kindergarten at age 4 or senior kindergarten at age 5, but this is not mandatory.	○	School principal makes promotion decisions, appealable to school board.
Quebec, Canada	Children must be 6 years old by September 30th to begin in September of that calendar year.	n/a	○	School boards determine promotion, Ministry sets rules for obtaining diplomas.
Abu Dhabi, UAE	Compulsory schooling begins at age 6. Children must be 6 years old by October 1st of the school year in which they enroll.	Parents sometimes place students in private schools that accept younger students, then transfer to the public system once the student has completed one or two years and has a promotion certificate.	●	Automatic promotion in Grades 1–5, except in special cases and with parental consent; promotion dependent on academic progress in Grades 6–8.
Dubai, UAE	Children can begin school the calendar year of their 5th birthday.	n/a	○	Varies by school type
Alabama, US	According to the code of Alabama 1875 Section 16-28-3, children must begin school at age 7.	According to the Code of Alabama 1875 Section 16-28-4, children typically begin primary school at age 7.	●	No policy
California, US	California law requires a child to be 6 years old on or before December 2 for the 2011-12 school year to enter Grade 1. However, the cut-off date for entry is in the process of being moved earlier by several months. (California Education Code [EC] Section 48010)	Although kindergarten is not required (EC Section 48200), most parents and guardians choose to enroll their children in kindergarten. Similar to the Grade 1 age requirement, districts must admit children at the beginning of the school year if they will be 5 years of age on or before December 2 for the 2011-12 school year.	●	No policy
Colorado, US	Children 6 years old on or before August 1st are required to begin school during that calendar year.	Parents may opt to send their children to private or parochial schools or home school them if they choose not to meet the state policy.	●	Policies are determined by local education agencies.
Connecticut, US	Children must begin school by the time they are 7 years old. A 4-year-old may enroll in preprimary education (kindergarten) at the beginning of a school year (August or September) if he or she will turn 5 on or before January 1 of that school year. Students progress from kindergarten to Grade 1 in the following year.	Some parents elect to delay school enrollment for younger children. State law allows this practice provided students are enrolled in school when they are 7 years of age.	○	Promotion and retention decisions are made locally at the district or school level.
Florida, US	Florida law, [Section 1003.21 (1)(a), Florida Statutes], specifies that all children who are 6 or who will be 6 by February 1st of that school year are required to attend school. If a child enters public school at age 6 without completing kindergarten, then they will be placed in kindergarten.	Florida law (Section 1003.21(1)(a)2, Florida Statutes) specifies that children who have attained the age of 5 on or before September 1 of the school year are eligible for admission to public kindergarten during that school year, based on rules prescribed by the school board. Children are eligible for kindergarten attendance provided they meet the age requirement.	○	Statewide, students are retained after Grade 3 if they do not pass the state reading assessment. Otherwise, policies for promotion and retention are determined by districts, based on academic performance.
Indiana, US	Children are not required to be in school until the school year in which they turn 7 years old. Children must be 5 years old on or before August 1st to begin kindergarten during that calendar year.	n/a	○	Students are retained after Grade 3 if they do not pass the state reading assessment.

● Yes
○ No

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 3: National Policies on School Entry and Promotion (Continued)

Country	Official Policy on Age of Entry to Primary School	Based on Parental Discretion, Usual Practice on Age of Entry to Primary School	Age of Entry Policy has Changed Within Past 10 Years	Policy on Promotion and Retention in Grades 1–8
Massachusetts, US	Each child must attend school beginning in September of the calendar year in which he or she turns 6. Each school committee may establish its own minimum permissible age for school attendance, provided that such age is not older than the mandatory minimum age established by state law 603CMR 8.00.	The Department of Elementary and Secondary Education may, upon petition of a school committee, waive the provisions of 603CMR 8.00 in order to avoid undue hardship to such school district.	○	No policy
Minnesota, US	Compulsory schooling begins at age 7. Children must be at least 5 years old by September 1st to begin kindergarten, or 6 years old by September 1st to begin Grade 1. (MN Statute 120A.20)	Any school board may establish a policy for admission at an earlier age.	○	No policy
North Carolina, US	Compulsory schooling begins at age 7. If the child is 5 years old on or before August 31st, the child is eligible to begin kindergarten.	The statute recognizes that some students will be presented for enrollment who can be more appropriately served at a higher grade level, and it authorizes the school principal to make such decisions.	○	No policy

● Yes
○ No

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Curriculum Questionnaire Results
Continue on the Following Page

Exhibit 4: Preprimary Education

Reported by National Research Coordinators

Country	Preprimary Education Available	Mandatory Preprimary Education	Number of Years Preprimary Education Required	National Preprimary Curriculum	Mathematics Included in National Preprimary Curriculum	Science Included in National Preprimary Curriculum
Armenia	●	○	n/a	○	n/a	n/a
Australia	●	○	n/a	Varies by state	Varies by state	Varies by state
Austria	●	●	1	○	n/a	n/a
Azerbaijan	●	○	n/a	○	n/a	n/a
Bahrain	●	○	n/a	○	n/a	n/a
Belgium (Flemish)	●	○	n/a	●	●	●
Botswana	●	○	n/a	●	●	○
Chile	●	○	n/a	●	●	●
Chinese Taipei	●	○	n/a	●	●	●
Croatia	●	○	n/a	○	n/a	n/a
Czech Republic	●	○	n/a	●	○	○
Denmark	●	●	1	●	●	●
England	●	○	n/a	●	●	●
Finland	●	○	n/a	●	●	●
Georgia	●	○	n/a	●	●	●
Germany	●	○	n/a	○	n/a	n/a
Ghana	●	●	2	●	●	●
Honduras	●	○	n/a	○	n/a	n/a
Hong Kong SAR	●	○	n/a	●	●	●
Hungary	●	●	1	●	●	●
Indonesia	●	○	n/a	●	○	○
Iran, Islamic Rep. of	●	○	n/a	●	●	●
Ireland	●	○	n/a	●	●	●
Israel	●	●	1	●	●	●
Italy	●	○	n/a	●	●	●
Japan	●	○	n/a	●	●	●
Jordan	●	○	n/a	●	●	●
Kazakhstan	●	●	1	●	●	●
Korea, Rep. of	●	○	n/a	●	●	●
Kuwait	●	○	n/a	○	n/a	n/a
Lebanon	●	○	n/a	●	○	○
Lithuania	●	○	n/a	●	●	●
Macedonia, Rep. of	●	○	n/a	●	●	●
Malaysia	●	○	n/a	●	●	○
Malta	●	○	n/a	●	●	●
Morocco	●	○	n/a	●	●	●
Netherlands	●	●	1	●	●	●
New Zealand	●	○	n/a	●	●	●
Northern Ireland	●	○	n/a	○	n/a	n/a
Norway	●	○	n/a	●	●	●
Oman	●	○	n/a	●	●	●
Palestinian Nat'l Auth.	●	○	n/a	●	●	●
Poland	●	●	1	●	○	○
Portugal	●	○	n/a	○	n/a	n/a
Qatar	●	○	n/a	●	●	●
Romania	●	○	n/a	●	●	●
Russian Federation	●	○	n/a	○	n/a	n/a
Saudi Arabia	●	○	n/a	●	●	●
Serbia	●	●	1	●	●	●
Singapore	●	○	n/a	○	n/a	n/a
Slovak Republic	●	○	n/a	●	●	●
Slovenia	●	○	n/a	●	●	●
South Africa	●	○	n/a	●	●	●
Spain	●	○	n/a	●	●	●
Sweden	●	○	n/a	●	●	●
Syrian Arab Republic	●	○	n/a	●	●	●
Thailand	●	○	n/a	○	n/a	n/a
Tunisia	●	○	n/a	●	●	●
Turkey	●	○	n/a	●	●	●
Ukraine	●	●	1	●	●	●
United Arab Emirates	●	○	n/a	●	●	●
United States	●	○	n/a	Varies by state	Varies by state	Varies by state
Yemen	●	○	n/a	○	n/a	n/a

A dash (–) indicates data not provided.

● Yes ○ No

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

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

Exhibit 4: Preprimary Education (Continued)

Country	Preprimary Education Available	Mandatory Preprimary Education	Number of Years Preprimary Education Required	National Preprimary Curriculum	Mathematics Included in National Preprimary Curriculum	Science Included in National Preprimary Curriculum
Benchmarking Participants—Responses Pertain to Benchmarking Provinces/Emirates/States						
Alberta, Canada	●	○	n/a	●	●	●
Ontario, Canada	●	○	n/a	●	●	●
Quebec, Canada	●	○	n/a	●	●	●
Abu Dhabi, UAE	●	○	n/a	●	●	●
Dubai, UAE	●	○	n/a	●	●	●
Alabama, US	●	○	n/a	●	–	●
California, US	●	○	n/a	○	n/a	n/a
Colorado, US	●	○	n/a	●	●	●
Connecticut, US	●	○	n/a	○	n/a	n/a
Florida, US	●	●	1	●	●	●
Indiana, US	●	○	n/a	●	●	●
Massachusetts, US	●	○	n/a	○	n/a	n/a
Minnesota, US	●	○	n/a	●	●	●
North Carolina, US	●	○	n/a	●	●	●

● Yes ○ No

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 5: Structural Characteristics of Mathematics Curriculum

Reported by National Research Coordinators

Country	National Curriculum	Grade 4: Grade to Grade Structure (Not Including Preprimary)	Grade 4: Year Introduced	Grade 4: Being Revised	Grade 8: Grade to Grade Structure (Not Including Preprimary)	Grade 8: Year Introduced	Grade 8: Being Revised	Examinations With Consequences for Individual Students	Grades at Which Examinations With Consequences for Individual Students are Given
Armenia	●	Grades 1–4	2006	○	Grades 5–9	2007	●	●	Grades 4, 9, 12
Australia	Varies by state	Varies by state, many have curricula for Grades 1–2, 3–4	Varies by state	●	Varies by state, many have curricula for Grades 5–6, 7–8	Varies by state	●	●	Varies by state, at end of secondary education
Austria	●	Grades 1–2, 3, 4	2003	○	–	–	–	○	n/a
Azerbaijan	●	Grades 1–4	2002	○	–	–	–	●	At end of basic secondary education (Grade 9) and secondary education (Grade 11)
Bahrain	●	Grades 1–3, 4–6	2009	●	Grades 7–9	2009	●	●	Grades 3, 6, 9, and at end of secondary education
Belgium (Flemish)	●	Grades 1–6	1997	○	–	–	–	○	n/a
Botswana	●	Grades 1–4	2002	○	Grades 5–7, 8–10	1996	●	●	At end of junior-secondary education (Grade 10), and senior-secondary education (Grade 12)
Chile	●	Grades 1–4	2002	●	Grades 5–8	2010	●	●	At the end of Grade 12
Chinese Taipei	●	Grades 1–2, 3–4	2001	●	Grades 5–6, 7–9	2003	●	●	Grades 9, 12
Croatia	●	Grades 1–8	2006	○	–	–	–	●	At end of secondary education
Czech Republic	●	Grades 1–3, 4–5	2007	○	–	–	–	●	At end of secondary education
Denmark	May vary by municipality, but based on national standards	Grades 1, 2, 3, 4	2009	●	–	–	–	●	At end of secondary education (Grade 12)
England	●	Grades 1, 2–5	1999	●	Grades 6–8	2007	●	●	Ages 11, 16, and 18
Finland	●	Grades 1–2, 3–5	2004	○	Grades 6–9	2004	○	●	Optional mathematics examination at end of secondary education
Georgia	●	Grades 1–6	2006	●	Grades 7–9	2006	●	●	Grade 12
Germany	Varies by state, but national standards	Varies by state, many have curricula for Grades 1–2, 3–4 (Berlin, Brandenburg: Grades 5–6)	2004 or later	Varies by state	Varies by state and courses of education	Varies by state	Varies by state	●	Grades 9/10, 12/13
Ghana	●	Grades 1–6	–	–	Grades 7–9	2007	○	●	At end of junior high school
Honduras	●	Grades 1–3, 4–6	2003	○	Grades 7–9	2003	○	○	n/a
Hong Kong SAR	●	Grades 1–6	2002	○	Grades 7–9	2001	○	●	Grade 12
Hungary	●	Grades 1–4	2007	●	Grades 5–6, 7–8	2007	●	●	At end of secondary education
Indonesia	●	Grades 1–6	–	–	Grades 7–9	2006	○	●	Grades 6, 9, 12
Iran, Islamic Rep. of	○	Grades 1–5	n/a	n/a	Grades 6–8	n/a	n/a	●	Grades 5, 8, 12
Ireland	●	Grades 1, 2, 3, 4	2002	○	–	–	–	●	Grades 9, 12
Israel	●	–	–	–	Grades 7–9	2010	●	●	At end of secondary education
Italy	●	Grades 1–3, 4–5	1985	●	Grades 6–8	1979	●	●	Grades 8, 13

● Yes
○ No

A dash (–) indicates data not provided.

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

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

Exhibit 5: Structural Characteristics of Mathematics Curriculum (Continued)

Country	National Curriculum	Grade 4: Grade to Grade Structure (Not Including Preprimary)	Grade 4: Year Introduced	Grade 4: Being Revised	Grade 8: Grade to Grade Structure (Not Including Preprimary)	Grade 8: Year Introduced	Grade 8: Being Revised	Examinations With Consequences for Individual Students	Grades at Which Examinations With Consequences for Individual Students are Given
Japan	●	Grades 1, 2, 3, 4	2009	○	Grades 5–6, 7, 8	2009	○	●	Grades 9, 12
Jordan	●	Grades 1–10	–	–	Grades 1–10	2005	●	●	Grade 12
Kazakhstan	●	Grades 1–4	2002	●	Grades 5–9	2002	●	●	Grade 9
Korea, Rep. of	●	Grades 1–6	2007	●	Grades 7–9	1997	●	●	Grade 12
Kuwait	●	Grades 1–5	2009	●	–	–	–	●	Grade 12
Lebanon	●	–	–	–	Grades 7–9	1998	●	●	Grade 9
Lithuania	●	Grades 1–2, 3–4	2008	○	Grades 5–6, 7–8	2008	○	●	Grades 10, 12
Macedonia, Rep. of	●	Grades 1, 2, 3, 4	2000	●	Grades 5, 6, 7, 8	2000	●	●	At end of secondary education
Malaysia	●	–	–	–	Grades 7–9	2003	○	●	Grade 11
Malta	●	Grades 1–2, 3–6	2005	●	–	–	–	●	At end of secondary education
Morocco	●	Grades 1–2, 3–4	2002	●	Grades 5–6, 7–9	2003	○	●	Grades 6, 9, 12
Netherlands	●	No compulsory grade structure, recommended for Grades 1–2, 3–4	2006	○	–	–	–	●	Grade 6 and at end of secondary education
New Zealand	●	No grade structure; curriculum is structured around 8 levels of learning	2010 for English curriculum; 2011 for Maori curriculum	○	No grade structure; curriculum is structured around 8 levels of learning	2010 for English curriculum; 2011 for Maori curriculum	○	●	In the last 3 years of secondary education
Northern Ireland	●	Grades 1–2, 3–5	2007	○	Grades 6–8	2007	○	●	Age 16, 18
Norway	●	Grades 1–2, 3–4	2006	○	Grades 5–7, 8–10	2006	○	●	Grade 10
Oman	●	Grades 1–4	1999	○	Grades 5–10	2003	○	●	Grades 5–12
Palestinian Nat'l Auth.	●	Grades 1–4	–	–	Grades 5–10	2003	●	●	Grade 12
Poland	●	Grades 1–3, 4–6	1999	●	–	–	–	●	At end of primary education, lower secondary education, and upper secondary education
Portugal	●	Grades 1–4	1992	●	–	–	–	●	Grades 9, 11–12
Qatar	●	Grades 1–6	2004	●	Grades 7–9	2005	○	●	Grade 12
Romania	●	Grades 1–2, 3, 4	2003	●	Grades 5, 6, 7, 8	2005	●	●	Grades 8, 12 (dependent on track)
Russian Federation	●	Grades 1–4	2004	●	Grades 5–9	2004	●	●	Grades 9, 11
Saudi Arabia	●	Grades 1, 2, 3, 4	2008	●	Grades 7–9	2008	●	●	Grade 12
Serbia	●	Grades 1, 2, 3, 4	2006	○	Grades 5, 6, 7, 8	–	–	●	Grade 8
Singapore	●	Grades 1, 2, 3, 4, 5, 6	2007	●	Grades 7, 8	2008	●	●	Grade 6, at end of secondary, and at end of pre-university education
Slovak Republic	●	Grades 1–4	1995	●	Grades 5–9	1997	●	●	Grade 9 (obligatory) and Grade 13 (optional)
Slovenia	●	Grades 1–9	1998	●	Grades 6–9	1998	●	●	Grade 9 and at end of secondary education
South Africa	●	Grades 1–3, 4–6	–	–	Grades 7–9	2002	●	●	Grade 12
Spain	●	Grades 1–2, 3–4	2007	○	Grades 5, 6, 7, 8	2007	○	●	Grades 6, 10
Sweden	●	Grades 1–3, 4–5	2000	●	Grades 6–9	2000	●	○	n/a

● Yes
○ No

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 5: Structural Characteristics of Mathematics Curriculum (Continued)

Country	National Curriculum	Grade 4: Grade to Grade Structure (Not Including Preprimary)	Grade 4: Year Introduced	Grade 4: Being Revised	Grade 8: Grade to Grade Structure (Not Including Preprimary)	Grade 8: Year Introduced	Grade 8: Being Revised	Examinations With Consequences for Individual Students	Grades at Which Examinations With Consequences for Individual Students are Given
Syrian Arab Republic	Yes	Grades 1–4	–	–	Grades 5–9	2007	No	Yes	Grades 9, 12
Thailand	Yes	Grades 1–3, 4–6	2008	Yes	Grades 7–9	2008	Yes	Yes	At end of secondary education
Tunisia	Yes	Grades 1–2, 3–4	2004	No	Grades 5–6, 7–9	2006	Yes	Yes	Grade 6, optional; Grade 9, mandatory
Turkey	Yes	Grades 1–3, 4–5	2004	No	Grades 6–8	2008	Yes	Yes	Grade 8
Ukraine	Yes	Grades 1–6	–	–	Grades 7–9	2004	Yes	Yes	Grades 4, 9, 11 (dependent on track)
United Arab Emirates	Yes	Grades 1–3, 4–5	2005	Yes	Grades 6–7, 8–9	2007	Yes	Yes	Grades 6–11, 12
United States	Varies by state	Varies by state and district	Varies by state	Varies by state	Varies by state and district	Varies by state	Varies by state	Varies by state	Many states require examination by the end of secondary education
Yemen	Yes	Grades 1–6	2000	Yes	Grades 7–9	–	–	Yes	Grades 9, 12
Benchmarking Participants—Responses Pertain to Benchmarking Provinces/Emirates/States									
Alberta, Canada	Yes	Grades 1, 2, 3, 4	2008	No	Grades 5, 6, 7, 8	2008	No	Yes	Grade 12
Ontario, Canada	Yes	Grades 1, 2, 3, 4	2005	No	Grades 5, 6, 7, 8	2005	No	Yes	Grade 9
Quebec, Canada	Yes	Grades 1–2, 3–4	2001	No	Grades 5–6, 7–8	2006	No	Yes	At end of secondary education
Abu Dhabi, UAE	Yes	Grades 1–5	2007	Yes	Grades 6–8	2007	Yes	Yes	Grades 6–11, 12
Dubai, UAE	Yes	Grades 1–3, 4–5 in public schools; Grades 1–5 in private schools	2005	Yes	Grades 6–7, 8–9 in public schools; Grades 6–9 in private schools	2007	Yes	Varies by school type	Varies by school type
Alabama, US	Statewide standards	Grades 1, 2, 3, 4	2009	Yes	Grades 5, 6, 7, 8	2009	Yes	Yes	Grade 11
California, US	Statewide standards	Grades 1, 2, 3, 4	1997	Yes	Grades 5, 6, 7, 8–12	1997	Yes	Yes	Grade 10
Colorado, US	Statewide standards	Grades 1–4	1995	Yes	Grades 5–8	1995	Yes	No	n/a
Connecticut, US	Statewide standards	Grades 1, 2, 3, 4	2005	Yes	Grades 5, 6, 7, 8	2005	Yes	No	n/a
Florida, US	Statewide standards	Grades 1, 2, 3, 4	2007	Yes	Grades 5, 6, 7, 8	2007	Yes	Yes	Grade 10
Indiana, US	Statewide standards	Grades 1, 2, 3, 4	2000	Yes	Grades 5, 6, 7, 8	2000	Yes	Yes	At end of secondary education
Massachusetts, US	Statewide standards	Grades 1-2, 3-4	2000	Yes	Grades 5-6, 7-8	2000	Yes	Yes	Grade 10
Minnesota, US	Statewide standards	Grades 1, 2, 3, 4	2008	No	Grades 5, 6, 7, 8	2008	No	Yes	Grade 11
North Carolina, US	Statewide standards	Grades 1, 2, 3, 4	2003	Yes	Grades 5, 6, 7, 8	2003	Yes	Yes	Grades 10, 11

● Yes
○ No

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 6: Structural Characteristics of Science Curriculum

Reported by National Research Coordinators

Country	National Curriculum	Grade 4			Grade 8			Examinations With Consequences for Individual Students	Grades at Which Examinations With Consequences for Individual Students are Given
		Grade to Grade Structure (Not Including Preprimary)	Year Introduced	Being Revised	Grade to Grade Structure (Not Including Preprimary)	Year Introduced	Being Revised		
Armenia	●	Grades 2–4	2006	○	Grades 5–9	2007	○	●	Grades 9, 12
Australia	Varies by state	Varies by state, many have curricula for Grades 1–2, 3–4	Varies by state	●	Varies by state, many have curricula for Grades 5–6, 7–8	Varies by state	●	●	Varies by state, at end of secondary education
Austria	●	Grades 1–2, 3, 4	2006	●	–	–	–	○	n/a
Azerbaijan	●	Grades 1–4	2002	○	–	–	–	●	At end of basic secondary education (Grade 9) and secondary education (Grade 11)
Bahrain	●	Grades 1–3, 4–6	2009	●	Grades 7–9	2010	●	●	Grades 3, 6, 9
Belgium (Flemish)	●	Grades 1–6	1997	●	–	–	–	○	n/a
Botswana	●	Grades 1–4	2002	○	Grades 5–7, 8–10	1996	●	●	At end of junior-secondary education (Grade 10), and senior-secondary education (Grade 12)
Chile	●	Grades 1–4	2002	●	Grades 5–8	2010	●	●	At the end of Grade 12
Chinese Taipei	●	Grades 1–2, 3–4	2001	●	Grades 5–6, 7–9	2003	○	●	Grades 9, 12
Croatia	●	Grades 1–8	2006	○	–	–	–	●	At end of secondary education (optional)
Czech Republic	●	Grades 1–3, 4–5	2007	○	–	–	–	●	At end of secondary education
Denmark	May vary by municipality, but based on national standards	Grades 1, 2, 3, 4	2009	○	–	–	–	●	At end of secondary education (Grade 12)
England	●	Grades 1, 2–5	1999	●	Grades 6–8	2007	●	●	Ages 16, 18
Finland	●	Grades 1–4	2004	○	Grades 5–6, 7–9	2004	○	●	Optional science examination at end of secondary education
Georgia	●	Grades 1–6	2006	●	Grades 7–9	2006	●	●	Grade 12
Germany	Varies by state	Varies by state, many have curricula for Grades 1–2, 3–4 (Berlin, Brandenburg: Grades 5–6)	2004 or later	Varies by state	Varies by state and courses of education	Varies by state	Varies by state	●	Grades 9/10, 12/13
Ghana	●	Grades 1–6	–	–	Grades 7–9	2007	○	●	At end of junior high school
Honduras	●	Grades 1–3, 4–6	2003	○	Grades 7–9	2003	○	○	n/a
Hong Kong SAR	●	Grades 1–6	2002	○	Grades 7–9	2000	○	●	Grade 12
Hungary	●	Grades 1–4	2007	●	Grades 5–6, 7–8	2007	●	●	At end of secondary education (optional)
Indonesia	●	Grades 1–6	–	–	Grades 7–9	2006	○	●	Grades 6, 9, 12
Iran, Islamic Rep. of	●	Grades 1–5	1994	●	Grades 6–8	2000	●	●	Grades 5, 8, 12
Ireland	●	Grades 1–2, 3–4	2003	○	–	–	–	●	Grades 9, 12
Israel	●	–	–	–	Grades 7–9	2010	●	●	At end of secondary education
Italy	●	Grades 1–3, 4–5	1985	●	Grades 6–8	1979	●	●	Grades 8, 13
Japan	●	Grades 3, 4	2009	○	Grades 5–6, 7–9	2009	○	●	Grades 9, 12
Jordan	●	Grades 1–10	–	–	Grades 1–10	2005	●	●	Grade 12
Kazakhstan	●	Grades 1–4	2002	●	Grades 5–9	2002	●	●	Grade 9

● Yes
○ No

A dash (–) indicates data not provided.

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 6: Structural Characteristics of Science Curriculum (Continued)

Country	National Curriculum	Grade 4: Grade to Grade Structure (Not Including Preprimary)	Grade 4: Year Introduced	Grade 4: Being Revised	Grade 8: Grade to Grade Structure (Not Including Preprimary)	Grade 8: Year Introduced	Grade 8: Being Revised	Examinations With Consequences for Individual Students	Grades at Which Examinations With Consequences for Individual Students are Given
Korea, Rep. of	●	Grades 1–2, 3–6	2007	●	Grades 7–9	1997	●	●	Grade 12
Kuwait	●	Grades 1–5	2009	●	–	–	–	●	Grade 12
Lebanon	●	–	–	–	Grades 7–9	1998	●	●	Grade 9
Lithuania	●	Grades 1–2, 3–4	2008	○	Grades 5–6, 7–8	2008	○	●	Grades 10, 12
Macedonia, Rep. of	●	Grades 1, 2, 3, 4	2000	●	Grades 5, 6, 7, 8	2000	●	●	At end of secondary education
Malaysia	●	–	–	–	Grades 7–9	2003	○	●	Grade 11
Malta	●	Grades 1–2, 3–6	2000	●	Grades 7–11	–	–	●	At end of secondary education
Morocco	●	Grades 1–2, 3–4	2002	●	Grades 5–6, 7–9	2003	○	●	Grades 6, 9, 12
Netherlands	●	No compulsory grade structure, recommended for Grades 1–2, 3–4	2006	○	–	–	–	●	Grade 6 and at end of secondary education
New Zealand	●	No grade structure; curriculum is structured around 8 levels of learning	2010 for English curriculum; 2011 for Maori curriculum	○	No grade structure; curriculum is structured around 8 levels of learning	2010 for English curriculum; 2011 for Maori curriculum	○	●	In the last 3 years of secondary education
Northern Ireland	●	Grades 1–3, 4–5	2007	○	Grades 6–8	2007	○	●	Age 16, 18
Norway	●	Grades 1–2, 3–4	2006	○	Grades 5–7, 8–10	2006	○	●	Grade 10
Oman	●	Grades 1–4	1998	●	Grades 5–10	2005	●	●	Grades 5–12
Palestinian Nat'l Auth.	●	Grades 1–4	–	–	Grades 5–10	2003	●	●	Grade 12
Poland	●	Grades 1–3, 4–6	1999	●	–	–	–	●	At end of primary education, lower secondary education, and upper secondary education
Portugal	●	Grades 1–4	1992	○	–	–	–	●	Grades 11–12
Qatar	●	Grades 1–6	2004	○	Grades 7–9	2004	○	●	Grade 12
Romania	●	Grades 1–2, 3, 4	2003	●	Physics: Grades 6–8 Biology: Grades 5–8 Chemistry: Grades 7–8 Geography: Grades 5–8	2005	●	●	Grade 12 (dependent on track)
Russian Federation	●	Grades 1–4	2004	●	Biology: Grades 6–9 Chemistry: Grades 8–9 Physics: Grades 7–9 Geography: Grades 6–9	2004	○	●	Grades 9, 11 (optional)
Saudi Arabia	●	Grades 1, 2, 3, 4	2008	●	Grades 7–9	2008	●	●	Grade 12
Serbia	●	Grades 1–2, 3–4	2006	○	Grades 5, 6, 7, 8	–	–	○	n/a
Singapore	●	Grades 3-4, 5-6	2008	●	Grades 7–8	2009	●	●	Grade 6, at end of secondary, and at end of pre-university education
Slovak Republic	●	Grades 1–2, 3–4	1995	●	Grades 5–9	1997	●	●	Grade 13 (optional)

● Yes
○ No

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 6: Structural Characteristics of Science Curriculum (Continued)

Country	National Curriculum	Grade 4: Grade to Grade Structure (Not Including Preprimary)	Grade 4: Year Introduced	Grade 4: Being Revised	Grade 8: Grade to Grade Structure (Not Including Preprimary)	Grade 8: Year Introduced	Grade 8: Being Revised	Examinations With Consequences for Individual Students	Grades at Which Examinations With Consequences for Individual Students are Given
Slovenia	●	Grades 1–3, 4–5	1998	●	Grades 6–7, 8–9	1998	●	●	At end of secondary education (optional)
South Africa	●	Grades 1–3, 4–6	–	–	Grades 7–9	2002	●	●	Grade 12
Spain	●	Grades 1–2, 3–4	2007	○	Grades 5, 6, 7, 8	2007	○	●	Grades 6, 10
Sweden	●	Grades 1–5	2000	●	Grades 6–9	2000	●	○	n/a
Syrian Arab Republic	●	Grades 1–4	–	–	Grades 5–9	2007	●	●	Grades 9, 12
Thailand	●	Grades 1–3, 4–6	2008	●	Grades 7–9	2008	●	●	At end of secondary education
Tunisia	●	Grades 1–2, 3–4	2004	○	Grades 5–6, 7–9	2006	●	●	Grade 6, optional; Grade 9, mandatory
Turkey	●	Grades 1–3, 4–5	2004	●	Grades 6–8	2008	●	●	Grade 8
Ukraine	●	Grades 1–6	–	–	Grades 7–11	2004	●	●	Grades 9, 11 (dependent on track)
United Arab Emirates	●	Grades 1–3, 4–5	2005	●	Grades 6–7, 8–9	2009	●	●	Grades 6–11, 12
United States	Varies by state	Varies by state and district	Varies by state	Varies by state	Varies by state and district	Varies by state	Varies by state	Varies by state	Many states require examination by the end of secondary education
Yemen	●	Grades 1–3, 4–6	2000	●	Grades 7–9	–	–	●	Grades 9, 12
Benchmarking Participants—Responses Pertain to Benchmarking Provinces/Emirates/States									
Alberta, Canada	●	Grades 1, 2, 3, 4	1996	○	Grades 5, 6, 7, 8	2002	○	●	Grade 12
Ontario, Canada	●	Grades 1, 2, 3, 4	2007	○	Grades 5, 6, 7, 8	2007	○	○	n/a
Quebec, Canada	●	Grades 1–2, 3–4	2001	○	Grades 5–6, 7–8	2006	○	●	At end of secondary education
Abu Dhabi, UAE	●	Grades 1–5	2007	●	Grades 6–8	2007	●	●	Grades 6–11, 12
Dubai, UAE	●	Grades 1–3, 4–5 in public schools; Grades 1–5 in private schools	2005	●	Grades 6–7, 8–9 in public schools; Grades 6–9 in private schools	2009	●	Varies by school type	Varies by school type
Alabama, US	Statewide standards	Grades 1, 2, 3, 4	2005	○	Grades 5, 6, 7, 8	2005	○	●	Grade 11
California, US	Statewide standards	Grades 1, 2, 3, 4	1998	●	Grades 5, 6, 7, 8	1998	●	○	n/a
Colorado, US	Statewide standards	Grades 1–2, 3–5	1995	●	Grades 6–8	1995	●	○	n/a
Connecticut, US	Statewide standards	Grades 1–2, 3–5	2004	○	Grades 6–8	2004	○	○	n/a
Florida, US	Statewide standards	Grades 1, 2, 3, 4	2008	○	Grades 5, 6, 7, 8	2008	○	○	n/a
Indiana, US	Statewide standards	Grades 1, 2, 3, 4	2000	○	Grades 5, 6, 7, 8	2000	○	○	n/a
Massachusetts, US	Statewide standards	Grades 1–2, 3–5	2006	●	Grades 6–8	2006	●	●	Grade 10
Minnesota, US	Statewide standards	Grades 1, 2, 3, 4	2010	○	Grades 5, 6, 7, 8	2010	○	○	n/a
North Carolina, US	Statewide standards	Grades 1, 2, 3, 4	2004	●	Grades 5, 6, 7, 8	2004	●	●	Grades 10, 11

● Yes
○ No

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 7: Components Prescribed by the Mathematics and Science Curricula

Reported by National Research Coordinators

Country	Goals and Objectives		Instructional Methods or Processes		Materials		Assessment Methods or Activities	
	Mathematics	Science	Mathematics	Science	Mathematics	Science	Mathematics	Science
Armenia	●	●	●	●	●	●	●	●
Australia	●	●	○	○	○	○	○	○
Austria	●	●	○	○	○	○	●	○
Azerbaijan	●	●	○	○	○	●	○	○
Bahrain	●	●	●	●	●	●	●	●
Belgium (Flemish)	●	●	○	○	○	○	○	○
Botswana	●	●	●	●	●	●	●	●
Chile	●	●	○	○	○	○	○	○
Chinese Taipei	●	●	●	●	●	●	●	●
Croatia	●	●	○	○	○	○	○	○
Czech Republic	●	●	○	○	○	○	○	○
Denmark	●	●	○	○	○	○	○	○
England	●	●	○	○	○	○	●	○
Finland	●	●	○	○	○	○	●	●
Georgia	●	●	●	●	●	●	●	●
Germany	●	●	●	●	○	○	○	●
Honduras	●	●	●	●	●	●	●	●
Hong Kong SAR	●	●	●	●	●	●	●	●
Hungary	●	●	○	○	○	○	○	○
Iran, Islamic Rep. of	●	●	●	●	●	●	●	●
Ireland	●	●	●	●	○	○	●	●
Italy	●	●	●	●	○	○	○	○
Japan	●	●	●	●	●	●	○	○
Kazakhstan	●	●	●	●	●	●	●	●
Korea, Rep. of	●	●	●	●	●	●	●	●
Kuwait	●	●	●	●	●	●	●	●
Lithuania	●	●	●	●	○	○	●	●
Malta	●	●	●	●	○	○	●	●
Morocco	●	●	●	●	●	●	●	●
Netherlands	●	●	○	○	○	○	○	○
New Zealand	●	●	○	○	○	○	○	○
Northern Ireland	●	●	○	○	○	○	●	●
Norway	●	●	○	○	○	○	●	●
Oman	●	●	●	●	●	●	●	●
Poland	●	●	○	○	○	○	○	○
Portugal	●	●	●	●	○	○	○	○
Qatar	●	●	●	●	○	○	○	●
Romania	●	●	●	●	●	●	●	●
Russian Federation	●	●	○	○	○	○	○	○
Saudi Arabia	●	●	●	●	●	●	●	●
Serbia	●	●	●	●	○	●	○	●
Singapore	●	●	●	●	●	●	●	○
Slovak Republic	●	●	○	○	○	○	○	○
Slovenia	●	●	●	●	○	○	●	●
Spain	●	●	○	○	○	○	●	●
Sweden	●	●	○	○	○	○	○	○
Thailand	●	●	●	●	●	●	●	●
Tunisia	●	●	○	○	●	●	○	○
Turkey	●	●	●	●	●	●	●	●
United Arab Emirates	●	●	●	●	●	●	●	●
United States	●	●	○	○	○	○	○	○
Yemen	●	●	●	●	●	●	●	●

● Yes
○ No

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 7: Components Prescribed by the Mathematics and Science Curricula (Continued)

Country	Goals and Objectives		Instructional Methods or Processes		Materials		Assessment Methods or Activities	
	Mathematics	Science	Mathematics	Science	Mathematics	Science	Mathematics	Science
Benchmarking Participants—Responses Pertain to Benchmarking Provinces/Emirates/States								
Alberta, Canada	●	●	●	●	○	○	○	○
Ontario, Canada	●	●	○	○	○	○	○	○
Quebec, Canada	○	○	○	○	○	○	○	○
Abu Dhabi, UAE	●	●	●	●	●	●	●	●
Dubai, UAE	●	●	●	●	●	●	●	●
Florida, US	●	●	○	○	○	○	○	○
North Carolina, US	●	●	○	○	○	○	○	○

● Yes

○ No

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 8: Components Prescribed by the Mathematics and Science Curricula

Reported by National Research Coordinators

Country	Goals and Objectives		Instructional Methods or Processes		Materials		Assessment Methods or Activities	
	Mathematics	Science	Mathematics	Science	Mathematics	Science	Mathematics	Science
Armenia	●	●	●	●	●	●	●	●
Australia	●	●	○	○	○	○	○	○
Bahrain	●	●	●	●	●	●	●	●
Botswana	●	●	●	●	●	●	●	●
Chile	●	●	○	○	○	○	○	○
Chinese Taipei	●	●	●	●	●	●	●	●
England	●	●	○	○	○	○	●	○
Finland	●	●	○	○	○	○	●	●
Georgia	●	●	●	●	●	●	●	●
Ghana	●	●	●	●	●	●	●	●
Honduras	●	●	●	●	○	○	●	●
Hong Kong SAR	●	●	●	●	●	●	●	●
Hungary	●	●	○	○	○	○	○	○
Indonesia	●	●	○	○	○	○	○	○
Iran, Islamic Rep. of	●	●	●	●	●	●	●	●
Israel	●	●	●	●	○	●	○	●
Italy	●	●	●	●	○	○	○	○
Japan	●	●	●	●	●	●	○	○
Jordan	●	●	●	●	●	●	●	●
Kazakhstan	●	●	●	●	●	●	●	●
Korea, Rep. of	●	●	●	●	●	●	●	●
Lebanon	●	●	●	●	●	●	●	●
Lithuania	●	●	●	●	○	○	●	●
Macedonia, Rep. of	●	●	●	●	●	●	●	●
Malaysia	●	●	●	●	●	●	●	●
Morocco	●	●	●	●	●	●	●	●
New Zealand	●	●	○	○	○	○	○	○
Norway	●	●	○	○	○	○	●	●
Oman	●	●	●	●	●	●	●	●
Palestinian Nat'l Auth.	●	●	○	●	●	●	●	○
Qatar	●	●	●	●	●	○	●	●
Romania	●	●	●	●	●	●	●	●
Russian Federation	●	●	○	○	○	○	○	○
Saudi Arabia	●	●	●	●	●	●	●	●
Singapore	●	●	●	●	●	●	●	○
Slovenia	●	●	●	●	○	○	●	●
South Africa	●	●	●	●	●	●	●	●
Sweden	●	●	○	○	○	○	○	○
Syrian Arab Republic	●	●	○	○	●	●	○	○
Thailand	●	●	●	●	●	●	●	●
Tunisia	●	●	●	○	●	●	●	●
Turkey	●	●	●	●	●	●	●	●
Ukraine	●	●	●	●	○	○	●	●
United Arab Emirates	●	●	●	●	●	●	●	●
United States	●	●	○	○	○	○	○	○

● Yes
○ No

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 8: Components Prescribed by the Mathematics and Science Curricula (Continued)

Country	Goals and Objectives		Instructional Methods or Processes		Materials		Assessment Methods or Activities	
	Mathematics	Science	Mathematics	Science	Mathematics	Science	Mathematics	Science
Benchmarking Participants—Responses Pertain to Benchmarking Provinces/Emirates/States								
Alberta, Canada	●	●	●	●	○	○	○	○
Ontario, Canada	●	●	○	○	○	○	○	○
Quebec, Canada	○	○	○	○	○	○	○	○
Abu Dhabi, UAE	●	●	●	●	●	●	●	●
Dubai, UAE	●	●	●	●	●	●	●	●
Alabama, US	●	●	○	○	○	○	●	○
California, US	●	●	●	●	●	●	○	○
Colorado, US	●	●	○	○	○	○	○	○
Connecticut, US	●	●	○	○	○	○	○	○
Florida, US	●	●	○	○	○	○	○	○
Indiana, US	●	●	○	●	○	○	●	○
Massachusetts, US	●	●	○	○	○	○	○	○
Minnesota, US	●	●	○	○	○	○	○	○
North Carolina, US	●	●	○	○	○	○	○	○

● Yes
○ No

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 9: Format in Which the Mathematics and Science Curricula Are Made Available

Reported by National Research Coordinators

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
Armenia	●	●	●	●	●	●	●	●	●	●
Australia	●	●	●	○	○	○	●	●	○	○
Austria	●	●	●	●	●	●	●	●	○	○
Azerbaijan	●	●	●	●	●	●	●	●	○	○
Bahrain	●	●	●	●	●	●	●	●	●	●
Belgium (Flemish)	●	●	●	●	○	○	●	●	●	●
Botswana	●	●	●	●	●	●	●	●	●	●
Chile	●	●	○	○	●	●	●	●	●	●
Chinese Taipei	●	●	●	●	○	○	○	●	○	●
Croatia	●	●	○	○	○	○	○	○	○	○
Czech Republic	●	●	○	○	●	●	○	○	○	○
Denmark	●	●	○	○	○	○	●	○	●	○
England	●	●	○	○	○	○	●	○	●	○
Finland	●	●	○	○	○	○	○	○	○	○
Georgia	●	●	○	○	●	●	○	○	○	○
Germany	●	●	●	●	●	●	○	○	○	○
Honduras	●	●	●	●	●	●	●	●	●	●
Hong Kong SAR	●	●	●	●	●	●	●	●	●	●
Hungary	●	●	○	○	○	○	○	○	○	○
Iran, Islamic Rep. of	○	●	●	●	●	●	●	●	○	○
Ireland	●	●	○	○	○	○	●	●	○	○
Italy	●	●	●	●	○	○	●	●	●	●
Japan	●	●	●	●	●	●	●	●	●	●
Kazakhstan	●	●	●	●	●	●	●	●	●	●
Korea, Rep. of	●	●	●	●	●	●	●	●	●	●
Kuwait	●	●	●	●	●	●	●	●	●	●
Lithuania	●	●	●	●	●	●	●	●	○	○
Malta	●	●	●	●	●	○	●	○	●	●
Morocco	●	●	●	●	●	●	●	●	●	●
Netherlands	●	●	●	●	○	○	●	○	●	○
New Zealand	●	●	●	●	○	○	●	●	●	●
Northern Ireland	●	●	●	●	○	○	○	○	○	○
Norway	●	●	●	●	○	○	○	○	○	○
Oman	●	●	●	●	○	●	●	●	○	●
Poland	●	●	○	○	○	○	○	○	○	○
Portugal	●	●	●	●	○	○	●	●	●	●
Qatar	●	●	○	●	●	●	○	●	○	●
Romania	●	●	○	○	●	●	●	●	●	●
Russian Federation	●	●	●	●	●	●	●	●	○	○
Saudi Arabia	●	●	●	●	○	○	●	●	●	●
Serbia	●	●	●	○	●	○	●	●	●	●
Singapore	●	●	●	●	●	●	●	●	●	●
Slovak Republic	●	●	○	○	●	●	○	○	○	○
Slovenia	●	●	●	●	●	●	○	○	○	○
Spain	●	●	●	●	○	○	○	○	○	○
Sweden	●	●	●	●	○	○	○	○	○	○
Thailand	●	●	●	●	○	○	●	●	●	●
Tunisia	●	●	○	○	●	●	●	●	○	○
Turkey	●	●	○	○	○	○	●	●	○	○
United Arab Emirates	●	●	●	●	●	●	●	●	●	●
United States	●	●	○	○	●	●	●	●	●	●
Yemen	●	●	●	●	●	●	●	●	○	●

● Yes
○ No

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 9: Format in Which the Mathematics and Science Curricula Are Made Available (Continued)

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
Benchmarking Participants—Responses Pertain to Benchmarking Provinces/Emirates/States										
Alberta, Canada	●	●	○	○	●	●	○	○	○	○
Ontario, Canada	●	●	○	○	○	○	○	○	○	○
Quebec, Canada	●	●	○	○	○	○	○	○	●	○
Abu Dhabi, UAE	●	●	●	●	●	●	●	●	●	●
Dubai, UAE	●	●	●	●	●	●	●	●	●	●
Florida, US	●	●	○	○	●	●	●	●	●	●
North Carolina, US	●	●	○	○	○	○	○	○	●	○

● Yes
○ No

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 10: Format in Which the Mathematics and Science Curricula Are Made Available

Reported by National Research Coordinators

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
Armenia	●	●	●	●	●	●	●	●	●	●
Australia	●	●	●	○	○	○	○	●	○	○
Bahrain	●	●	●	○	●	●	●	●	●	●
Botswana	●	●	●	●	●	●	●	●	●	●
Chile	●	●	○	○	●	●	●	●	●	●
Chinese Taipei	●	●	●	●	○	○	○	●	○	●
England	●	●	○	●	○	○	●	○	●	○
Finland	●	●	○	○	○	○	○	○	○	○
Georgia	●	●	○	○	●	●	○	○	○	○
Ghana	●	●	●	●	●	●	●	●	●	○
Honduras	●	●	●	●	○	○	○	○	○	○
Hong Kong SAR	●	●	●	●	●	●	●	●	●	●
Hungary	●	●	○	○	○	○	○	○	○	○
Indonesia	●	●	●	●	○	●	●	●	●	●
Iran, Islamic Rep. of	○	●	●	●	●	●	●	●	○	○
Israel	●	●	○	●	○	●	●	●	●	●
Italy	●	●	●	●	○	○	●	●	○	○
Japan	●	●	●	●	●	●	●	●	●	●
Jordan	●	●	●	●	●	●	●	●	●	●
Kazakhstan	●	●	●	●	●	●	●	●	●	●
Korea, Rep. of	●	●	●	●	●	●	●	●	●	●
Lebanon	●	●	●	●	●	●	●	●	○	●
Lithuania	●	●	●	●	●	●	●	●	○	○
Macedonia, Rep. of	●	●	●	●	○	○	●	●	●	●
Malaysia	●	●	●	●	●	●	●	●	●	●
Morocco	●	●	●	●	●	●	●	●	○	●
New Zealand	●	●	●	●	○	○	●	●	●	●
Norway	●	●	●	●	○	○	○	○	○	○
Oman	●	●	●	●	○	●	●	●	○	●
Palestinian Nat'l Auth.	●	●	●	●	○	○	●	●	○	●
Qatar	●	●	○	●	○	●	○	●	○	●
Romania	●	●	○	○	●	●	●	●	●	●
Russian Federation	●	●	●	●	●	●	○	●	○	○
Saudi Arabia	●	●	●	●	○	○	●	●	●	●
Singapore	●	●	●	●	●	●	●	●	●	●
Slovenia	●	●	●	●	●	●	○	○	○	○
South Africa	●	●	●	●	●	●	●	●	○	○
Sweden	●	●	●	●	○	○	○	○	○	○
Syrian Arab Republic	●	●	●	●	●	●	○	○	○	○
Thailand	●	●	●	●	○	●	●	●	●	●
Tunisia	●	●	○	○	●	●	●	●	○	●
Turkey	●	●	○	○	○	○	●	●	○	○
Ukraine	●	●	●	●	●	●	●	●	●	●
United Arab Emirates	●	●	●	●	●	●	●	●	●	●
United States	●	●	○	○	●	●	●	●	●	●

● Yes
○ No

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

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

Exhibit 10: Format in Which the Mathematics and Science Curricula Are Made Available (Continued)

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
Benchmarking Participants—Responses Pertain to Benchmarking Provinces/Emirates/States										
Alberta, Canada	●	●	○	○	●	●	○	○	○	○
Ontario, Canada	●	●	○	○	○	○	○	○	○	○
Quebec, Canada	●	●	○	○	○	○	○	○	○	○
Abu Dhabi, UAE	●	●	●	●	●	●	●	●	●	●
Dubai, UAE	●	●	●	●	●	●	●	●	●	●
Alabama, US	●	●	○	●	○	●	○	○	●	○
California, US	●	●	○	○	●	●	●	●	○	○
Colorado, US	●	●	○	○	○	○	○	○	○	○
Connecticut, US	●	●	●	●	○	○	○	●	○	●
Florida, US	●	●	○	○	●	●	●	●	●	●
Indiana, US	●	●	○	●	●	○	○	●	●	●
Massachusetts, US	●	●	○	○	○	○	○	○	○	○
Minnesota, US	●	●	○	○	○	○	○	○	●	○
North Carolina, US	●	○	○	○	○	○	○	○	●	●

● Yes
○ No

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 11: Cognitive Processes Emphasized in the Intended Mathematics Curriculum

TIMSS 2011 Mathematics 4th Grade

Reported by National Research Coordinators

Country	Mastering Basic Skills and Procedures	Applying Mathematics in Real-life Contexts	Reasoning Mathematically
Armenia	●	◉	◉
Australia	●	●	●
Austria	●	●	◉
Azerbaijan	◉	○	⊙
Bahrain	●	●	◉
Belgium (Flemish)	●	●	◉
Botswana	●	●	●
Chile	◉	◉	◉
Chinese Taipei	●	◉	◉
Croatia	●	●	●
Czech Republic	●	◉	⊙
Denmark	◉	◉	●
England	●	◉	◉
Finland	●	◉	◉
Georgia	●	●	●
Germany	●	◉	◉
Honduras	●	◉	⊙
Hong Kong SAR	●	●	●
Hungary	●	◉	◉
Iran, Islamic Rep. of	●	●	◉
Ireland	●	◉	◉
Italy	●	●	◉
Japan	●	●	●
Kazakhstan	●	●	●
Korea, Rep. of	●	●	●
Kuwait	●	●	●
Lithuania	●	●	◉
Malta	●	●	●
Morocco	◉	◉	◉
Netherlands	◉	◉	●
New Zealand	◉	◉	●
Northern Ireland	●	●	●
Norway	◉	●	◉
Oman	●	●	◉
Poland	●	◉	⊙
Portugal	●	◉	◉
Qatar	●	●	●
Romania	●	◉	●
Russian Federation	●	◉	⊙
Saudi Arabia	●	●	●
Serbia	●	⊙	◉
Singapore	●	●	●
Slovak Republic	●	◉	⊙
Slovenia	◉	◉	⊙
Spain	●	●	◉
Sweden	●	●	●
Thailand	●	●	●
Tunisia	●	●	◉
Turkey	●	●	●
United Arab Emirates	●	●	●
United States	●	◉	◉
Yemen	●	◉	◉

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

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

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

Exhibit 11: Cognitive Processes Emphasized in the Intended Mathematics Curriculum (Continued)

TIMSS 2011 Mathematics 4th Grade

Country	Mastering Basic Skills and Procedures	Applying Mathematics in Real-life Contexts	Reasoning Mathematically
Benchmarking Participants—Responses Pertain to Benchmarking Provinces/Emirates/States			
Alberta, Canada	◉	◉	●
Ontario, Canada	●	●	●
Quebec, Canada	◉	●	●
Abu Dhabi, UAE	●	⊙	⊙
Dubai, UAE	●	●	●
Florida, US	●	◉	◉
North Carolina, US	●	●	●

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

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 12: Cognitive Processes Emphasized in the Intended Mathematics Curriculum

TIMSS 2011 Mathematics 8th Grade

Reported by National Research Coordinators

Country	Mastering Basic Skills and Procedures	Applying Mathematics in Real-life Contexts	Reasoning Mathematically
Armenia	●	◉	◉
Australia	●	●	●
Bahrain	●	●	◉
Botswana	●	●	◉
Chile	◉	◉	◉
Chinese Taipei	●	◉	◉
England	●	◉	◉
Finland	●	●	●
Georgia	◉	◉	●
Ghana	◉	◉	⊙
Honduras	◉	●	◉
Hong Kong SAR	●	◉	●
Hungary	●	◉	●
Indonesia	◉	◉	◉
Iran, Islamic Rep. of	●	●	◉
Israel	●	●	●
Italy	●	●	●
Japan	●	●	●
Jordan	●	●	◉
Kazakhstan	●	●	●
Korea, Rep. of	●	●	●
Lebanon	●	◉	⊙
Lithuania	●	◉	◉
Macedonia, Rep. of	◉	◉	⊙
Malaysia	●	●	◉
Morocco	◉	⊙	◉
New Zealand	◉	◉	●
Norway	◉	●	◉
Oman	●	●	◉
Palestinian Nat'l Auth.	●	◉	⊙
Qatar	●	◉	●
Romania	●	◉	●
Russian Federation	●	⊙	◉
Saudi Arabia	●	●	●
Singapore	●	●	●
Slovenia	◉	⊙	◉
South Africa	●	●	●
Sweden	●	●	●
Syrian Arab Republic	●	⊙	◉
Thailand	●	●	●
Tunisia	●	●	●
Turkey	●	●	●
Ukraine	●	◉	◉
United Arab Emirates	●	●	●
United States	●	◉	◉

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

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

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

Exhibit 12: Cognitive Processes Emphasized in the Intended Mathematics Curriculum (Continued)

TIMSS 2011 Mathematics 8th Grade

Country	Mastering Basic Skills and Procedures	Applying Mathematics in Real-life Contexts	Reasoning Mathematically
Benchmarking Participants—Responses Pertain to Benchmarking Provinces/Emirates/States			
Alberta, Canada	◉	◉	●
Ontario, Canada	●	●	●
Quebec, Canada	◉	●	●
Abu Dhabi, UAE	●	◉	◉
Dubai, UAE	●	●	●
Alabama, US	●	●	●
California, US	●	⊙	●
Colorado, US	●	◉	●
Connecticut, US	●	●	●
Florida, US	●	◉	◉
Indiana, US	●	●	●
Massachusetts, US	●	●	●
Minnesota, US	●	●	◉
North Carolina, US	●	●	●

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

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 13: Cognitive Processes and Scientific Inquiry Emphasized in the Intended Science Curriculum

Reported by National Research Coordinators

Country	Knowing Basic Science Facts and Principles	Applying Science in Real-life Contexts	Providing Explanations or Justifications about What Is Being Studied	Designing and Planning Experiments or Investigations	Conducting Experiments or Investigations
Armenia	●	◉	●	◉	◉
Australia	◉	●	●	●	●
Austria	●	●	⊙	⊙	◉
Azerbaijan	●	○	⊙	⊙	⊙
Bahrain	●	●	●	●	●
Belgium (Flemish)	●	●	◉	◉	◉
Botswana	●	◉	⊙	⊙	⊙
Chile	◉	◉	◉	◉	◉
Chinese Taipei	●	●	●	◉	●
Croatia	⊙	◉	◉	◉	◉
Czech Republic	●	◉	◉	⊙	⊙
Denmark	◉	◉	●	⊙	○
England	●	◉	◉	◉	●
Finland	●	◉	⊙	○	◉
Georgia	●	◉	◉	◉	◉
Germany	●	●	◉	●	●
Honduras	◉	◉	⊙	○	○
Hong Kong SAR	●	◉	◉	◉	◉
Hungary	⊙	◉	⊙	○	⊙
Iran, Islamic Rep. of	◉	●	⊙	◉	◉
Ireland	●	●	◉	◉	●
Italy	◉	●	●	●	◉
Japan	●	●	●	●	●
Kazakhstan	●	●	●	●	●
Korea, Rep. of	●	●	◉	●	●
Kuwait	●	●	●	●	●
Lithuania	◉	◉	◉	◉	◉
Malta	◉	◉	◉	◉	◉
Morocco	⊙	⊙	◉	⊙	⊙
Netherlands	●	●	◉	⊙	⊙
New Zealand	●	◉	●	○	◉
Northern Ireland	●	●	●	●	●
Norway	⊙	●	⊙	⊙	◉
Oman	●	●	●	●	●
Poland	◉	◉	⊙	○	◉
Portugal	◉	◉	◉	⊙	◉
Qatar	●	◉	◉	◉	◉
Romania	●	◉	●	◉	◉
Russian Federation	◉	◉	◉	◉	◉
Saudi Arabia	●	●	●	◉	●
Serbia	●	◉	◉	◉	◉
Singapore	●	●	●	◉	●
Slovak Republic	●	◉	⊙	⊙	◉
Slovenia	●	◉	●	◉	⊙
Spain	●	●	◉	◉	◉
Sweden	●	◉	●	●	●
Thailand	●	●	●	●	●
Tunisia	●	●	⊙	◉	⊙
Turkey	●	●	●	●	●
United Arab Emirates	●	●	●	●	●
United States	●	◉	◉	●	●
Yemen	●	⊙	⊙	⊙	⊙

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

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

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

Exhibit 13: Cognitive Processes and Scientific Inquiry Emphasized in the Intended Science Curriculum (Continued)

Country	Knowing Basic Science Facts and Principles	Applying Science in Real-life Contexts	Providing Explanations or Justifications about What Is Being Studied	Designing and Planning Experiments or Investigations	Conducting Experiments or Investigations
Benchmarking Participants—Responses Pertain to Benchmarking Provinces/Emirates/States					
Alberta, Canada	◉	◉	◉	◉	●
Ontario, Canada	●	●	●	●	●
Quebec, Canada	●	◉	●	◉	◉
Abu Dhabi, UAE	●	◉	◉	◉	●
Dubai, UAE	●	●	●	●	●
Florida, US	●	◉	◉	●	●
North Carolina, US	●	●	●	●	●

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

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 14: Cognitive Processes and Scientific Inquiry Emphasized in the Intended Science Curriculum

Reported by National Research Coordinators

Country	Knowing Basic Science Facts and Principles	Applying Science in Real-life Contexts	Providing Explanations or Justifications about What Is Being Studied	Designing and Planning Experiments or Investigations	Conducting Experiments or Investigations
Armenia	●	●	●	◉	◉
Australia	●	●	●	●	●
Bahrain	●	●	●	◉	●
Botswana	◉	◉	●	◉	●
Chile	●	◉	●	●	●
Chinese Taipei	●	◉	●	⊙	⊙
England	●	◉	●	●	●
Finland	●	●	◉	⊙	◉
Georgia	●	◉	◉	◉	◉
Ghana	●	◉	⊙	⊙	⊙
Honduras	◉	◉	⊙	○	○
Hong Kong SAR	●	●	◉	●	●
Hungary	●	◉	⊙	⊙	◉
Indonesia	●	●	⊙	◉	◉
Iran, Islamic Rep. of	◉	●	◉	◉	◉
Israel	●	●	●	●	●
Italy	●	◉	●	●	●
Japan	●	●	●	●	●
Jordan	●	●	◉	◉	◉
Kazakhstan	●	●	●	●	●
Korea, Rep. of	●	◉	◉	●	●
Lebanon	◉	◉	◉	◉	◉
Lithuania	●	◉	◉	◉	◉
Macedonia, Rep. of	◉	⊙	◉	⊙	⊙
Malaysia	●	●	●	●	●
Morocco	◉	◉	◉	⊙	◉
New Zealand	●	◉	●	◉	●
Norway	◉	◉	●	●	●
Oman	●	●	●	●	●
Palestinian Nat'l Authority	●	◉	◉	⊙	◉
Qatar	●	◉	◉	◉	◉
Romania	●	◉	●	◉	◉
Russian Federation	●	◉	◉	◉	◉
Saudi Arabia	●	●	●	◉	●
Singapore	●	●	●	◉	●
Slovenia	●	◉	●	◉	⊙
South Africa	●	●	●	●	●
Sweden	●	◉	●	●	●
Syrian Arab Republic	●	◉	◉	◉	◉
Thailand	●	●	●	●	●
Tunisia	●	◉	◉	◉	⊙
Turkey	●	●	●	●	●
Ukraine	◉	◉	◉	⊙	⊙
United Arab Emirates	●	●	●	●	●
United States	●	◉	◉	●	●

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

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 14: Cognitive Processes and Scientific Inquiry Emphasized in the Intended Science Curriculum (Continued)

Country	Knowing Basic Science Facts and Principles	Applying Science in Real-life Contexts	Providing Explanations or Justifications about What Is Being Studied	Designing and Planning Experiments or Investigations	Conducting Experiments or Investigations
Benchmarking Participants—Responses Pertain to Benchmarking Provinces/Emirates/States					
Alberta, Canada	●	●	●	●	●
Ontario, Canada	●	●	●	●	●
Quebec, Canada	●	●	●	◉	●
Abu Dhabi, UAE	◉	◉	◉	⊙	◉
Dubai, UAE	●	●	●	●	●
Alabama, US	●	◉	●	◉	◉
California, US	●	◉	◉	●	◉
Colorado, US	●	⊙	⊙	●	●
Connecticut, US	●	●	●	●	●
Florida, US	●	◉	◉	●	●
Indiana, US	●	◉	◉	◉	◉
Massachusetts, US	●	●	●	●	●
Minnesota, US	●	⊙	◉	◉	●
North Carolina, US	●	●	●	●	●

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

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 15: Methods Used to Evaluate the Implementation of the Mathematics and Science Curricula

TIMSS 2011 Mathematics & Science 4th Grade

Reported by National Research Coordinators

Country	Visits by Inspectors / Supervisors		Research Programs		School Self-Evaluation		National or Regional Assessments	
	Mathematics	Science	Mathematics	Science	Mathematics	Science	Mathematics	Science
Armenia	●	●	●	○	○	●	●	○
Australia	○	○	○	○	●	●	●	○
Austria	●	●	○	○	○	○	○	○
Azerbaijan	●	●	○	○	●	●	●	●
Bahrain	●	●	○	○	●	●	●	●
Belgium (Flemish)	●	●	●	●	●	●	○	○
Botswana	●	●	●	●	●	●	●	●
Chile	●	●	●	●	●	●	●	●
Chinese Taipei	●	●	●	○	●	●	●	○
Croatia	○	○	○	○	○	○	●	●
Czech Republic	●	●	●	●	●	●	○	○
Denmark	○	○	●	●	○	○	●	●
England	●	●	○	○	●	●	●	●
Finland	○	○	●	●	●	●	●	●
Georgia	○	○	○	○	●	●	●	○
Germany	●	●	○	○	●	●	●	○
Honduras	●	●	○	○	○	●	●	○
Hong Kong SAR	●	●	●	●	●	●	●	○
Hungary	○	○	●	●	●	●	●	●
Iran, Islamic Rep. of	●	●	●	●	○	○	●	●
Ireland	●	●	●	○	●	○	●	○
Italy	○	○	○	○	●	●	○	○
Japan	●	●	●	●	●	●	●	●
Kazakhstan	●	●	●	●	●	●	●	●
Korea, Rep. of	●	●	●	●	●	●	●	●
Kuwait	●	●	●	●	●	●	●	●
Lithuania	●	●	○	○	●	●	○	○
Malta	●	●	○	●	●	●	●	●
Morocco	●	●	○	○	○	○	●	●
Netherlands	●	●	●	●	●	●	○	○
New Zealand	●	●	●	●	●	●	○	○
Northern Ireland	●	●	●	●	●	●	●	●
Norway	○	○	●	●	●	●	●	○
Oman	●	●	●	●	●	●	●	●
Poland	●	●	●	○	●	○	○	○
Portugal	○	○	○	○	●	●	●	○
Qatar	●	●	○	●	●	●	●	●
Romania	●	●	●	●	●	●	●	●
Russian Federation	●	●	●	●	●	●	●	●
Saudi Arabia	●	●	○	○	●	●	●	●
Serbia	●	●	●	○	●	●	●	○
Singapore	○	○	○	○	●	●	●	●
Slovak Republic	●	●	○	○	●	●	○	○
Slovenia	○	○	●	●	●	●	●	●
Spain	●	●	○	○	●	●	●	●
Sweden	●	●	○	○	●	●	○	○
Thailand	●	●	●	●	●	●	●	●
Tunisia	●	●	○	○	○	○	○	○
Turkey	●	●	●	●	○	○	○	○
United Arab Emirates	●	●	●	●	●	●	●	●
United States	●	●	●	●	●	●	●	●
Yemen	●	●	○	●	○	●	●	●

● Yes

○ No

A dash (–) indicates data not provided.

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 15: Methods Used to Evaluate the Implementation of the Mathematics and Science Curricula (Continued)

Country	Visits by Inspectors / Supervisors		Research Programs		School Self-Evaluation		National or Regional Assessments	
	Mathematics	Science	Mathematics	Science	Mathematics	Science	Mathematics	Science
Benchmarking Participants—Responses Pertain to Benchmarking Provinces/Emirates/States								
Alberta, Canada	○	○	○	○	○	○	●	○
Ontario, Canada	○	○	○	○	●	●	●	○
Quebec, Canada	○	○	○	○	○	○	○	○
Abu Dhabi, UAE	●	●	○	○	●	●	●	●
Dubai, UAE	●	●	○	○	●	●	●	●
Florida, US	●	●	●	●	●	●	●	●
North Carolina, US	○	○	○	●	–	●	●	●

● Yes

○ No

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 16: Methods Used to Evaluate the Implementation of the Mathematics and Science Curricula

TIMSS 2011 Mathematics & Science 8th Grade

Reported by National Research Coordinators

Country	Visits by Inspectors / Supervisors		Research Programs		School Self-Evaluation		National or Regional Assessments	
	Mathematics	Science	Mathematics	Science	Mathematics	Science	Mathematics	Science
Armenia	●	●	●	●	●	●	●	●
Australia	○	○	○	○	●	●	●	●
Bahrain	●	●	○	○	●	●	●	●
Botswana	●	●	●	●	●	●	●	●
Chile	●	●	●	●	●	●	●	●
Chinese Taipei	○	●	●	●	○	●	●	○
England	●	●	○	○	●	●	●	○
Finland	○	○	●	●	●	●	●	●
Georgia	○	○	○	○	●	●	●	○
Ghana	●	●	●	●	○	○	○	○
Honduras	●	●	○	○	○	○	●	○
Hong Kong SAR	●	●	●	●	●	●	●	○
Hungary	○	○	●	●	●	●	●	●
Indonesia	●	○	○	●	●	●	●	●
Iran, Islamic Rep. of	●	●	●	●	○	○	●	●
Israel	●	●	●	●	●	●	●	●
Italy	○	○	○	○	●	●	●	○
Japan	●	●	●	●	●	●	●	●
Jordan	●	●	●	●	○	○	●	●
Kazakhstan	●	●	●	●	●	●	●	●
Korea, Rep. of	●	●	●	●	●	●	●	●
Lebanon	●	○	●	●	●	●	●	●
Lithuania	●	●	○	○	●	●	○	○
Macedonia, Rep. of	●	●	●	●	●	●	●	○
Malaysia	●	●	○	●	●	●	●	●
Morocco	●	●	●	●	○	●	●	●
New Zealand	●	●	●	●	●	●	○	○
Norway	○	○	●	●	●	●	●	○
Oman	●	●	●	●	●	●	●	●
Palestinian Nat'l Auth.	●	●	●	○	○	○	●	●
Qatar	●	●	○	●	○	●	●	●
Romania	●	●	●	●	●	●	●	○
Russian Federation	○	●	●	●	●	●	●	●
Saudi Arabia	●	●	○	○	●	●	●	●
Singapore	○	○	○	○	●	●	●	●
Slovenia	○	○	●	●	●	●	●	●
South Africa	○	○	●	●	●	●	●	●
Sweden	●	●	○	○	●	●	○	○
Syrian Arab Republic	●	●	●	●	●	●	●	●
Thailand	●	●	●	●	●	●	●	●
Tunisia	●	●	○	○	○	○	●	○
Turkey	●	●	●	●	○	○	○	○
Ukraine	●	●	●	●	●	●	●	●
United Arab Emirates	●	●	●	●	●	●	●	●
United States	●	●	●	●	●	●	●	●

● Yes
○ No

A dash (–) indicates data not provided.

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 16: Methods Used to Evaluate the Implementation of the Mathematics and Science Curricula (Continued)

Country	Visits by Inspectors / Supervisors		Research Programs		School Self-Evaluation		National or Regional Assessments	
	Mathematics	Science	Mathematics	Science	Mathematics	Science	Mathematics	Science
Benchmarking Participants—Responses Pertain to Benchmarking Provinces/Emirates/States								
Alberta, Canada	○	○	○	○	○	○	●	●
Ontario, Canada	○	○	●	○	●	●	●	○
Quebec, Canada	○	○	○	○	○	○	○	○
Abu Dhabi, UAE	●	●	○	○	●	●	●	●
Dubai, UAE	●	●	○	○	●	●	●	●
Alabama, US	●	●	○	○	●	●	●	●
California, US	○	○	●	●	●	●	●	●
Colorado, US	○	○	○	○	○	●	●	●
Connecticut, US	○	○	○	○	●	●	●	●
Florida, US	●	●	●	●	●	●	●	●
Indiana, US	●	○	○	○	●	○	●	●
Massachusetts, US	○	○	○	○	●	●	●	●
Minnesota, US	○	○	●	○	●	●	●	●
North Carolina, US	○	○	○	●	–	●	●	●

● Yes

○ No

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 17: Instructional Time Devoted to Mathematics and Science Curriculum

Reported by National Research Coordinators

Country	Percent of Total Instructional Time	
	Mathematics	Science
Armenia	20%	8%
Australia	Varies by state	Varies by state
Austria	Approximately 18%	Approximately 2–3%
Azerbaijan	16%	9%
Bahrain	17%	10%
Belgium (Flemish)	18–21%	7–10%
Botswana	9%	9%
Chile	15%	8%
Chinese Taipei	10–15%	10–15%
Croatia	22%	17%
Czech Republic	Not specified in curriculum	Not specified in curriculum
Denmark	Not specified in curriculum	Not specified in curriculum
England	Not specified in curriculum	Not specified in curriculum
Finland	Not specified in curriculum	Not specified in curriculum
Georgia	20%	16%
Germany	Varies by state (approximately 19%)	Varies by state (approximately 9%)
Honduras	Not specified in curriculum	Not specified in curriculum
Hong Kong SAR	12–15%	12–15%
Hungary	17–23%	4–8%
Iran, Islamic Rep. of	16%	13%
Ireland	13%	4%
Italy	20%	10%
Japan	18%	11%
Kazakhstan	17%	7%
Korea, Rep. of	14%	10%
Kuwait	14%	9%
Lithuania	19%	4%
Malta	19%	8%
Morocco	16%	5%
Netherlands	Not specified in curriculum	Not specified in curriculum
New Zealand	Not specified in curriculum	Not specified in curriculum
Northern Ireland	Not specified in curriculum	Not specified in curriculum
Norway	17%	6%
Oman	17%	13%
Poland	Not specified in curriculum	Not specified in curriculum
Portugal	30%	20%
Qatar	20%	10%
Romania	15–25%	5–10%
Russian Federation	16%	6%
Saudi Arabia	Not specified in curriculum	Not specified in curriculum
Serbia	25%	10%
Singapore	22%	8%
Slovak Republic	19%	12%
Slovenia	21%	13%
Spain	15–19%	6–8%
Sweden	Not specified in curriculum	Not specified in curriculum
Thailand	16%	8%
Tunisia	13%	7%
Turkey	13%	10%
United Arab Emirates	15%	11%
United States	Varies by school district	Varies by school district
Yemen	19%	8%
Benchmarking Participants—Responses Pertain to Benchmarking Provinces/Emirates/States		
Alberta, Canada	15%	15%
Ontario, Canada	Not specified in curriculum	Not specified in curriculum
Quebec, Canada	20%	Not specified in curriculum
Abu Dhabi, UAE	14%	11%
Dubai, UAE	Varies by school type	Varies by school type
Florida, US	Not specified in curriculum	Not specified in curriculum
North Carolina, US	Not specified in curriculum	Not specified in curriculum

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 18: Instructional Time Devoted to Mathematics and Science Curriculum

Reported by National Research Coordinators

Country	Percent of Total Instructional Time	
	Mathematics	Science
Armenia	16%	25%
Australia	Varies by state	Varies by state
Bahrain	17%	13%
Botswana	13%	13%
Chile	15%	10%
Chinese Taipei	10–15%	10–15%
England	Not specified in curriculum	Not specified in curriculum
Finland	Not specified in curriculum	Not specified in curriculum
Georgia	13%	13%
Ghana	25%	15%
Honduras	Not specified in curriculum	Not specified in curriculum
Hong Kong SAR	12–15%	10–15%
Hungary	10–15%	17–24%
Indonesia	Not specified in curriculum	Not specified in curriculum
Iran, Islamic Rep. of	12%	11%
Israel	17%	17%
Italy	13%	6%
Japan	10%	14%
Jordan	15%	12%
Kazakhstan	14%	25%
Korea, Rep. of	12%	12%
Lebanon	17%	17%
Lithuania	14%	14%
Macedonia, Rep. of	13%	26%
Malaysia	15%	15%
Morocco	13%	13%
New Zealand	Not specified in curriculum	Not specified in curriculum
Norway	12%	10%
Oman	17%	18%
Palestinian Nat'l Auth.	15%	12%
Qatar	17%	15%
Romania	13%	24–27%
Russian Federation	16%	26%
Saudi Arabia	Not specified in curriculum	Not specified in curriculum
Singapore	13%	15%
Slovenia	14%	25%
South Africa	18%	13%
Sweden	Not specified in curriculum	Not specified in curriculum
Syrian Arab Republic	13%	13%
Thailand	10%	10%
Tunisia	11%	10%
Turkey	13%	13%
Ukraine	14%	28%
United Arab Emirates	15%	11%
United States	Varies by school district	Varies by school district
Benchmarking Participants—Responses Pertain to Benchmarking Provinces/Emirates/States		
Alberta, Canada	11%	11%
Ontario, Canada	Not specified in curriculum	Not specified in curriculum
Quebec, Canada	17%	10%
Abu Dhabi, UAE	17%	12%
Dubai, UAE	Varies by school type	Varies by school type
Alabama, US	Not specified in curriculum	Not specified in curriculum
California, US	Not specified in curriculum	Not specified in curriculum
Colorado, US	Not specified in curriculum	Not specified in curriculum
Connecticut, US	Not specified in curriculum	Not specified in curriculum
Florida, US	Not specified in curriculum	Not specified in curriculum
Indiana, US	Not specified in curriculum	Not specified in curriculum
Massachusetts, US	Not specified in curriculum	Not specified in curriculum
Minnesota, US	Not specified in curriculum	Not specified in curriculum
North Carolina, US	Not specified in curriculum	Not specified in curriculum

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 19: Process for Approving Mathematics and Science Textbooks

Reported by National Research Coordinators

Country	Description of Process
Armenia	The Special Institute of Ministry of Education organizes a best book competition every year from which the winning textbook in each subject area is selected for all schools.
Australia	No process for approving textbooks
Austria	Authors submit their textbooks/materials to the Federal Ministry of Education, Arts & Culture for evaluation based on ministry-defined criteria. One important aspect is coverage of the entire curriculum. Only approved textbooks are permitted for school use. While many textbooks are approved, none are explicitly recommended; teachers may freely choose from the list.
Azerbaijan	The Ministry of Education defines and announces the list of newly created textbooks, and announces competitions in any subject according to the rules for creating new textbooks. After the Ministry's announcement, publishing houses send applications for participation in the competition. The competition commission determines the list of acceptable proposals and presents them to the Textbook Assessment Council. In other cases, the Ministry orders textbooks from authors and publishing companies. These textbooks are sent to the Textbook Assessment Council. The Ministry holds the right to publish and distribute ordered textbooks, and approves textbooks based on the Textbook Assessment Council's presentation. Early each year, the Ministry prepares and approves the list and number of copies of textbooks to meet demand. Textbooks for general education schools are prepared for 5 years.
Bahrain	Textbooks are continuously revised in response to feedback from mathematics/science teachers, mathematics/science educational supervisors, measurement and evaluation educational specialists, and parents.
Belgium (Flemish)	No process for approving textbooks
Botswana	Panels of judges review books under the aegis of the Department of Curriculum Development and Evaluation.
Chile	The Ministry oversees a bidding process for the development of textbooks in major subjects, including mathematics and science, and selects the most appropriate in terms of the quality of content, activities, and teacher's guide. Use is not compulsory, but the Ministry strongly recommends them and they are used by most schools. The Ministry freely distributes these textbooks to all subsidized schools at the beginning of each school year.
Chinese Taipei	Mathematic textbooks are reviewed by a committee established by the National Academy for Educational Research of Taiwan. Publishers invite teachers, science educators, and curriculum designers to develop science textbooks, which are then evaluated by a Ministry of Education-invited committee. Those textbooks that pass examination can be published for use in schools.
Croatia	The School Textbooks Board and expert committees for each individual subject or area are in charge of evaluating textbooks. Approval of new textbooks is conducted according to the elements and instruments for textbook and handbook evaluation, and in correspondence with textbook standards, educational programs, and goals. The Ministry of Education, Science and Sports prescribes textbooks for mathematics and science.
Czech Republic	The Ministry of Education publishes the list of approved textbooks and teaching texts in the Bulletin of the Ministry of Education, Youth and Sports, and on the Internet. These are approved on the basis of compliance with educational objectives stipulated in the Education Act, in the Framework Educational Programs, and legal regulations. The approximate 3-month approval process begins when a publisher submits a textbook. The ministry asks two reviewers, one of whom usually is from a higher education institution, for comments with which the publisher fine-tunes the textbook. If the reviewers have strong differences of opinion about a textbook, a third is used.
Denmark	No process for approving textbooks
England	No process for approving textbooks
Finland	No process for approving textbooks
Georgia	The National Curriculum and Assessment Center has a rigorous and uniformly applied process for approval of textbooks and instructional materials. Analysts of the mathematics and science textbooks are evenly divided between experienced, practicing classroom teachers, and higher education faculty knowledgeable about research on mathematics/science learning and teaching. Math and science textbooks are an important component of instruction, because many teachers rely on textbooks to present students with math and science activities to further learning.
Germany	Varies by state, grade, and subject. In the state with the largest population, North Rhine-Westphalia: for Mathematics, extended approval by the ministry, which requires a review of authorized specialists; for Science, simplified approval by the ministry only.
Honduras	The Japanese International Cooperation Agency has led the process of designing, writing, and pilot-testing mathematics textbooks. No process for approving science textbooks.
Hong Kong SAR	Mathematics and science textbooks are vetted by appropriate Textbook Reviewing Panels of the Education Bureau's Textbook Committee, made up of experienced teachers. Publishers may submit proposed mathematics and science textbooks to the Education Bureau for review. Textbooks corresponding to the curriculum, and in accordance with acceptable standards, are classified as "Recommended" and included in a Recommended Textbook List for reference by schools.
Hungary	Textbooks must be accredited by the Ministry of Education's Educational Authority.
Iran, Islamic Rep. of	Once a textbook is completed, a 1-year pilot evaluates the text through review of feedback from selected teachers, mathematics or science educators, and mathematicians, when applicable, in the capital city and throughout the country.
Ireland	No process for approving textbooks
Italy	Textbooks are selected by teachers, using parent representatives' advice. The school teaching board then must approve them. The Ministry of Education establishes the expenditure ceiling for the entire set of textbooks for each grade. There is only one textbook that includes both mathematics and science.

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 19: Process for Approving Mathematics and Science Textbooks (Continued)

Country	Description of Process
Japan	Textbooks must pass a sequence of evaluations before receiving approval for use in Japanese schools. First, companies submit drafts of proposed textbooks to the Ministry of Education, Culture, Sports, Science and Technology. There they are checked in accordance with the Courses of Study by an official council composed of university professors and teachers. Once revisions are complete and the textbook has received approval, local boards of education select books from a list of authorized textbooks for schools under their jurisdiction. The authorization process is generally conducted every 4 years, with results presented to the public the following year.
Kazakhstan	An expert group approves textbooks which are then confirmed by the Ministry of Education and Science.
Korea, Rep. of	There is a screening system for textbooks.
Kuwait	Textbooks are approved by the educational research and curricular sector at the Ministry of Education before circulation to schools.
Lithuania	To be included in the textbook database, textbooks must receive two positive reviews from independent experts and confirmation of the Lithuanian language committee stating that they correspond to the language standards. The choice of textbooks used for learning is the responsibility of the teaching staff, and schools and teachers can choose from a wide range of texts in the database.
Malta	An expression of interest is issued to all suppliers and proposals are submitted. A board of experts evaluates these using pre-established criteria and chooses the best textbook series to meet curricular goals. No process for approving science textbooks.
Morocco	Textbook writers submit manuscripts for review and approval in accordance with detailed specifications to a jury panel appointed by the Ministry of National Education. Accepted manuscripts are printed in time for the academic year. Due to the newly adopted pedagogy of integration, supplementary materials and various teaching guides for teachers and supervisors have been designed. Regionally, inspectors and teachers develop supplementary mathematics and science materials linked to students' everyday life in each of the 16 regions.
Netherlands	No process for approving textbooks
New Zealand	No process for approving textbooks
Northern Ireland	No process for approving textbooks
Norway	No process for approving textbooks
Oman	Mathematics and science instruction textbooks are produced by the Ministry of Education, which forms teams to translate specific grades' curriculum goals and learning outcomes into textbook lessons and activities. These teams consist of specialists in each subject, a supervisor, a curriculum officer, an assessment officer, and a teacher educator. A focus group of teachers in particular grades in different parts of the country check the written material, proposed activities, and time frames for each unit. Textbooks then go to a higher committee headed by the Undersecretary of Education for approval. Special committees are formed to check the suitability of commercially-produced material before purchase by the ministry or schools.
Poland	Publishers must submit every new textbook for expert review by Ministry of Education designates. Based on their evaluation, the Minister may approve the textbook for use in schools. There are no separate textbooks for mathematics or science in Grades 1–3. Mathematics and science content is covered by some chapters in general textbooks.
Portugal	Textbooks must be approved by a scientific committee regarding evaluation criteria defined by the Ministry of Education. Teachers/schools then choose from an extensive approved list according to their preferences.
Qatar	Textbooks are aligned with National Curriculum Standards and only text series with a high percentage of correlation are used in schools. The Supreme Education Council provides schools with a list of approved texts. Science textbooks are reviewed by science curriculum specialists for curriculum standard coverage, language, cultural acceptability, and depth of knowledge.
Romania	The National Assessment and Evaluation Center, an agency of the Ministry of Education, Research, Youth and Sports, holds a national competition for mathematics and science textbook selection every 5 years for primary and lower secondary levels. Textbooks meeting specific criteria are approved by the ministry. Teachers can choose textbooks or the teaching material from the list of approved texts according to individual class needs.
Russian Federation	The textbooks are reviewed by experts from the Russian Academy of Sciences and Russian Academy of Education who evaluate whether textbooks are in accordance with the requirements of the Educational Standards and age characteristics of primary school students. The federal list of the recommended textbooks for use in primary school is based on the experts' review.
Saudi Arabia	Specialized committees in mathematics and science under the Ministry of Education's General Directorate of Curriculum revise and approve textbooks.
Serbia	Publishers submit textbooks to the Ministry of Education and Science. Drafts are then delivered to the Institute for Improving Education, which prepares a professional evaluation according to prescribed quality standards. The draft and evaluation are then passed to the National Educational Council (NEC) and the Ministry, where the Minister approves those textbooks recommended by the NEC. Each potential textbook undergoes an expert committee review that recommends the acceptance or rejection of the textbook.
Singapore	For each new or revised syllabus in mathematics and science, commercial publishers are invited to develop and publish textbooks and related materials, such as activity books or workbooks, for use in schools. These textbooks and materials undergo a stringent review and authorization process by the Ministry of Education. Only those meeting the quality standards and requirements of the respective syllabi will be approved.
Slovak Republic	The Ministry of Education (MoE) announces competitions for textbooks with specific requirements and various authors can apply. Once approved by a specially-assembled committee and two reviewers, authors submit draft textbooks to the National Institute for Education (NIE) or National Institute for Professional Education (NIPE). If requirements are met, NIE or NIPE complete an approval report used by MoE to issue "approval closure." There can be various textbooks with approval closure for a particular subject. Approved textbooks are listed in a national register of textbooks from which schools may choose and receive textbooks free of charge. If MoE does not issue the approval closure, further competition is announced.

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 19: Process for Approving Mathematics and Science Textbooks (Continued)

Country	Description of Process
Slovenia	Textbooks used in schools must be approved by the National Expert Council for General Education. To be approved, textbooks are independently reviewed by subject matter specialists regarding content, coverage of the curriculum objectives, and design according to criteria set by the Ministry for Education.
Spain	Textbooks must be approved by the Education Board.
Sweden	No process for approving textbooks
Thailand	All textbooks must be approved by expert committees before being printed and marketed to schools.
Tunisia	Textbooks are evaluated by a team of experts before they can be used in classrooms.
Turkey	All textbooks must be approved by the Board of Education. In the approval process, an expert commission examines the textbooks with respect to standards defined by the Board. Textbooks meeting the standards are approved.
United Arab Emirates	Textbooks are reviewed by a textbook preparation committee as well as by curriculum department administrators, who then assign the committee the task of editing the text per reviewer recommendations.
United States	States use one of two methods to select the textbooks used in their schools. The majority of states allow school districts or schools to choose the textbooks they will use. A number of states (21 in 2008) have a process for approving or recommending textbooks and materials to be used in local districts and schools. Because some of these states, known as textbook adoption states, have large student populations (e.g., California, Florida, and Texas), they can greatly influence the market of published textbooks. School districts' roles in approving textbooks also vary. School districts in many states have a process for approving or recommending textbooks and materials, while districts in other states leave the decision to individual schools.
Yemen	Every textbook must be approved by the ministerial Curricula Supreme Committee before it is sent to the Ministry of Education's design unit and printing presses.
Benchmarking Participants—Responses Pertain to Benchmarking Provinces/Emirates/States	
Alberta, Canada	There are different processes depending on program needs and publisher ability to address them. In the case of the Grade 4 resources, a Call for Resources is issued in which all publishers are invited to submit a completed student and teacher resource package addressing the philosophy and pedagogy of the program of studies and at least 95% of specified outcomes. A representative group of teachers reviews each resource and analyzes the content against a comprehensive set of criteria. Items related to the philosophy of the program include the following: the extent to which the resource addresses the outcomes, the instructional and technical design, and social considerations (including the inclusion of Francophone, First Nations, Metis and Inuit perspectives; Western Canadian content; and respectful representations of people). Resources meeting the criteria are then considered authorized resources, from which school authorities select those that best suit student needs.
Ontario, Canada	Ontario has a Trillium List containing the textbook titles approved by the Minister of Education for use in Ontario schools. These textbooks have been subjected to a rigorous evaluation in accordance with criteria specified in the Guidelines for Approval of Textbooks. Key eligibility criteria include the following: congruence with curriculum policy; provision of a teacher resource guide; Canadian orientation and product; and detailed criteria for content and format. Ontario has a separate list of Ministry approved textbooks for both English-language and French-language schools. In addition to the criteria identified above, French-language textbooks must integrate cultural content and references to support student identity building, and must align with the Aménagement Linguistique Policy for the French-language schools in Ontario.
Quebec, Canada	Separate Ministry departments are responsible for didactic material and the approval of this material.
Abu Dhabi, UAE	All resources, including textbooks, are approved by the Abu Dhabi Education Council. A curriculum and resource review process is used for public schools. Private schools have their curriculum approved but they are free to choose resources.
Dubai, UAE	Textbooks for schools using the national curriculum are reviewed by a textbook preparation committee as well as by curriculum department administrators, who then assign the committee the task of editing the text per reviewer recommendations. No process for approving textbooks is specified for private schools that teach other curricula.
Florida, US	Policies and procedures for the adoption of instructional materials are developed annually by the Department of Education. Selected subject areas are called for adoption each year on a rotating basis. Prior to each adoption, the Department of Education publishes the Instructional Materials Specifications for the subjects to be adopted. These specifications outline the courses for which materials are being sought, as well as the standards that those materials are expected to meet. State Instructional Materials Reviewers review and evaluate the materials submitted for adoption. It is the Commissioner of Education who formally adopts the recommendations of the reviewers. The Commissioner may accept the recommendations or amend them. Each county (Local Education Agency) may choose which materials to purchase from the adoption list. Florida schools and school districts must purchase adopted materials through the publisher's Florida depository.
North Carolina, US	Each year, a call (the Invitation to Submit Textbooks for Evaluation and Adoption in North Carolina) goes to publishers to request submission of textbooks/instructional materials for evaluation. Prior to the call going out, a Curriculum Review Committee is appointed from qualified educators across the state to review relevant curricula and to write the criteria for submission of materials. The criteria are included in the call letter sent to publishers the following April. Evaluation sheets are written using the same criteria. The entire adoption process from this point, throughout the final adoption, stresses compatibility with the Standard Course of Study and the appropriateness of the materials for the teachers and students who are the end users.

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 20: Process for Approving Mathematics and Science Textbooks

Reported by National Research Coordinators

Country	Description of Process
Armenia	The Special Institute of Ministry of Education organizes a best book competition every year from which the winning textbook in each subject area is selected for all schools.
Australia	No process for approving textbooks
Bahrain	Textbooks are continuously revised in response to feedback from mathematics/science teachers, mathematics/science educational supervisors, measurement and evaluation educational specialists, and parents.
Botswana	Panels of teachers review books under the aegis of the Department of Curriculum Development and Evaluation.
Chile	The Ministry oversees a bidding process for the development of textbooks in major subjects, including mathematics and science, and selects the most appropriate in terms of the quality of content, activities, and teacher's guide. Use is not compulsory, but the Ministry strongly recommends them and they are used by most schools. The Ministry freely distributes these textbooks to all subsidized schools at the beginning of each school year.
Chinese Taipei	Private and public companies develop teaching materials to meet the objectives prescribed by General Guidelines of the Grade 1-9 Curriculum. All teaching materials must be reviewed by a committee organized by the Ministry of Education. For each textbook, there are 3 phases of revision based on the feedback from committee members. If the publisher is unable to finish revisions within these 3 phases, the textbook is returned without approval. If the review committee accepts the textbook, the textbook publisher can sell it to the public. The committee members for science textbooks are composed of scientists, curriculum specialists, teachers, and administrators.
England	No process for approving textbooks
Finland	No process for approving textbooks
Georgia	The National Curriculum and Assessment Center has a rigorous and uniformly applied process for approval of textbooks and instructional materials. Analysts of the mathematics and science textbooks are evenly divided between experienced, practicing classroom teachers, and higher education faculty knowledgeable about research on mathematics/science learning and teaching. Math and science textbooks are an important component of instruction, because many teachers rely on textbooks to present students with math and science activities to further learning.
Ghana	Textbook policy mandates private publishers to recruit writers to write textbooks for publication. Developed materials are assessed by a committee, established by the Ministry of Education, for recommendation to schools.
Honduras	No process for approving textbooks
Hong Kong SAR	Mathematics and science textbooks are vetted by appropriate Textbook Reviewing Panels of the Education Bureau's Textbook Committee, made up of experienced teachers. Publishers may submit proposed mathematics and science textbooks to the Education Bureau for review. Textbooks corresponding to the curriculum, and in accordance with acceptable standards, are classified as "Recommended" and included in a Recommended Textbook List for reference by schools.
Hungary	Textbooks must be accredited by the Ministry of Education's Educational Authority.
Indonesia	All mandatory books must be approved by content specialists.
Iran, Islamic Rep. of	Once a textbook is completed, a 1-year pilot evaluates the text through review of feedback from selected teachers, mathematics or science educators, and mathematicians, when applicable, in the capital city and throughout the country.
Israel	Private companies and publishers write and submit textbooks for approval to the Ministry of Education. First, two experts (a mathematician and an expert in math education for math, and an academic and an expert in teaching science for science) evaluate textbooks based on a list of criteria. Corrections are then made, if necessary, based on a report before textbooks are submitted to the Chief Inspector for final approval. Criteria are currently being revised.
Italy	Textbooks are selected by teachers, using parent representatives' advice. The school teaching board then must approve them. The Ministry of Education establishes the expenditure ceiling for the entire set of textbooks for each grade.
Japan	Textbooks must pass a sequence of evaluations before receiving approval for use in Japanese schools. First, companies submit drafts of proposed textbooks to the Ministry of Education, Culture, Sports, Science and Technology. There they are checked in accordance with the Courses of Study by an official council composed of university professors and teachers. Once revisions are complete and the textbook has received approval, local boards of education select books from a list of authorized textbooks for schools under their jurisdiction. The authorization process is generally conducted every 4 years, with results presented to the public the following year.
Jordan	Mathematics and science curriculum committees submit textbooks to expert panels in mathematics and science curricula, where they are revised and recommendations are made to the education board for approval. The education board reviews the textbooks and can approve them or ask for modifications or amendments.
Kazakhstan	An expert group approves textbooks which are then confirmed by the Ministry of Education and Science.
Korea, Rep. of	There is a textbook screening system.
Lebanon	The Educational Center for Research and Development handles the process for approving mathematics textbooks. Submitted science textbooks should comply with the objectives of the national curriculum (general objectives of education in Lebanon and specific objectives of the subject), citizenship policies in Lebanon, and social and cultural values in Lebanon.
Lithuania	To be included in the textbook database, textbooks must receive two positive reviews from independent experts and confirmation of the Lithuanian language committee stating that they correspond to the language standards. The choice of textbooks used for learning is the responsibility of the teaching staff, and schools and teachers can choose from a wide range of texts in the database.
Macedonia, Rep. of	Textbooks used in the schools must be approved by the Ministry of Education and Science.
Malaysia	Textbooks are approved by the Ministry of Education's Textbook Division.

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 20: Process for Approving Mathematics and Science Textbooks (Continued)

Country	Description of Process
Morocco	Textbook writers submit manuscripts for review and approval in accordance with detailed specifications to a jury panel appointed by the Ministry of National Education, in keeping with the provisions of the National Charter for Education and Training. Successful manuscripts appear in print prior to the start of the academic year. All mathematics and science textbooks are validated through this process.
New Zealand	No process for approving textbooks
Norway	No process for approving textbooks
Oman	Mathematics and science instruction textbooks are produced by the Ministry of Education, which forms teams for converting curriculum goals and learning outcomes into textbook lessons and activities. These teams consist of specialists in each subject, from Higher education, a supervisor, a curriculum officer, an assessment officer, and a teacher educator. A focus group of teachers in particular grades in different parts of the country check the material, proposed activities, and the time frame for each unit. Textbooks then go to a higher committee headed by the Undersecretary of Education for approval. Special committees are formed to check the suitability of commercially-produced materials before purchase by the ministry or schools. Based on the results of TIMSS 2007, the Scope and Sequence for Science was revised and developed further to be in line with international learning outcomes.
Palestinian Nat'l Auth.	Mathematics textbooks are approved by the Ministerial Curriculum Committee, the socialized ministerial subject committee, and a field committee made up of experienced teachers and supervisors. Science textbooks also are approved by three committees, including the ministerial approval committee, using feedback from central and field workshops, and a district science committee made up of experienced teachers and science supervisors.
Qatar	Textbooks are aligned with National Curriculum Standards and only text series with a high percentage of correlation are used in schools. The Supreme Education Council provides schools with a list of approved texts. Science textbooks are reviewed by science curriculum specialists for curriculum standard coverage, language, cultural acceptability, and depth of knowledge.
Romania	The National Assessment and Evaluation Center, an agency of the Ministry of Education, Research, Youth and Sports, holds a national competition for mathematics and science textbook selection every 5 years for primary and lower secondary levels. Textbooks meeting specific criteria are approved by the ministry. Teachers can choose textbooks or the teaching material from the list of approved texts according to individual class needs.
Russian Federation	The textbooks are reviewed by experts from the Russian Academy of Sciences and Russian Academy of Education who evaluate whether textbooks are in accordance with the requirements of the Educational Standards and age characteristics of basic school students. The federal list of the recommended textbooks for use in basic school is based on the experts' review.
Saudi Arabia	Specialized committees in mathematics and science under the Ministry of Education's General Directorate of Curriculum revise and approve textbooks.
Singapore	For each new or revised syllabus in mathematics and science, commercial publishers are invited to develop and publish textbooks and related materials, such as activity books or workbooks, for use in schools. These textbooks and materials undergo a stringent review and authorization process by the Ministry of Education. Only those meeting the quality standards and requirements of the respective syllabi will be approved.
Slovenia	Textbooks used in schools must be approved by the National Expert Council for General Education. To be approved, textbooks are independently reviewed by subject matter specialists regarding content, coverage of the curriculum objectives, and design according to criteria set by the Ministry for Education.
South Africa	The National Department of Basic Education approves quality textbooks and provides lists to the provinces, which provide the lists to teachers and schools, who select textbooks for their students.
Sweden	No process for approving textbooks
Syrian Arab Republic	The process for approving textbooks for mathematics and science instruction is done by the Ministry of Education's Directorate of Curriculum and Guidance. Textbooks are first edited by the editing committee and science textbooks are then studied by teachers to determine whether they suit students and provide feedback. Mathematics and science textbooks are then sent to the university for evaluation by specialists. Those approved at this stage are printed directly.
Thailand	All textbooks must be approved by expert committees before being printed and marketed to schools.
Tunisia	Textbooks are evaluated by a team of experts before they can be used in classrooms.
Turkey	All textbooks must be approved by the Board of Education. In the approval process, an expert commission examines the textbooks with respect to standards defined by the Board. Textbooks meeting the standards are approved.
Ukraine	Special commissions in different subject areas screen materials. These commissions, made up of scientists, method experts, and teachers, recommend textbooks for publication for school use.
United Arab Emirates	Textbooks are reviewed by a textbook preparation committee as well as by curriculum department administrators, who then assign the committee the task of editing the text per reviewer recommendations.
United States	States use one of two methods to select the textbooks used in their schools. The majority of states allow school districts or schools to choose the textbooks they will use. A number of states (21 in 2008) have a process for approving or recommending textbooks and materials to be used in local districts and schools. Because some of these states, known as textbook adoption states, have large student populations (e.g., California, Florida, and Texas), they can greatly influence the market of published textbooks. School districts' roles in approving textbooks also vary. School districts in many of the states have a process for approving or recommending textbooks and materials, while districts in other states leave the decision to individual schools.

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 20: Process for Approving Mathematics and Science Textbooks (Continued)

Country	Description of Process
Benchmarking Participants—Responses Pertain to Benchmarking Provinces/Emirates/States	
Alberta, Canada	There are different processes depending on program needs and publisher ability to address them. For example, a Call for Resources is issued in which all publishers are invited to submit a completed student and teacher resource package addressing the philosophy and pedagogy of the program of studies and at least 95% of specified outcomes. A representative group of teachers reviews each resource and analyzes the content against a comprehensive set of criteria. Items related to the philosophy of the program include the following: the extent to which the resource addresses the outcomes, the instructional and technical design, and social considerations (including the inclusion of Francophone, First Nations, Metis and Inuit perspectives; Western Canadian content; and respectful representations of people). Resources meeting the criteria are then considered authorized resources, from which school authorities select those that best suit student needs.
Ontario, Canada	Ontario has a Trillium List containing the textbook titles approved by the Minister of Education for use in Ontario schools. These textbooks have been subjected to a rigorous evaluation in accordance with criteria specified in the Guidelines for Approval of Textbooks. Key eligibility criteria include the following: congruence with curriculum policy; provision of a teacher resource guide; Canadian orientation and product; and detailed criteria for content and format. Ontario has a separate list of Ministry approved textbooks for both English-language and French-language schools. In addition to the criteria identified above, the French-language textbooks must integrate cultural content and references to support student identity building, and must align with the Aménagement Linguistique Policy for the French-language schools in Ontario.
Quebec, Canada	Separate Ministry departments are responsible for didactic material and the approval of this material.
Abu Dhabi, UAE	Publishers are engaged to produce resources which are then approved by the Abu Dhabi Education Council for use in public schools. Private schools are free to select the resources they feel best support their curriculum.
Dubai, UAE	Textbooks for schools using the national curriculum are reviewed by a textbook preparation committee as well as by curriculum department administrators, who then assign the committee the task of editing the text per reviewer recommendations. No process for approving textbooks is specified for private schools that teach other curricula.
Alabama, US	The State Textbook Law provides for the creation and composition of the State Textbook Committee to consider the merit of textbooks offered for use in the public elementary and high schools of Alabama. The textbook adoption process for each content area is on a 6-year cycle. At the conclusion of the review process, the textbook committee makes recommendations to the State Board of Education in writing, for approval and/or rejection, of textbooks. Based upon the recommendations of the State Textbook Committee, the State Board of Education adopts a list of textbooks which local boards of education may adopt for use in their systems. Local textbook committees recommend textbooks to the local board of education from the State Board of Education's list of adoptions or from a list submitted to the committee by the local superintendent. Local boards of education cannot adopt textbooks nor expend public funds for textbooks that have been rejected by the State Board of Education.
California, US	California Education Code describes the process for the adoption of instructional materials for kindergarten through grade eight and mandates that submitted materials be evaluated for consistency with the criteria and standards in the State Board of Education's (SBE) curriculum frameworks. The Instructional Quality Commission serves as an advisory body to the SBE in the evaluation and adoption process. Instructional materials are broadly defined to include textbooks, technology-based materials, and other educational materials. The SBE traditionally adopts only basic instructional materials programs (i.e., programs that are designed for use by students and their teachers as a principal learning resource and meet the basic organization and content requirements of a full course of study, which is generally one school year in length).
Colorado, US	No process for approving textbooks
Connecticut, US	No process for approving textbooks
Florida, US	Policies and procedures for the adoption of instructional materials are developed annually by the Department of Education. Selected subject areas are called for adoption each year on a rotating basis. Prior to each adoption, the Department of Education publishes the Instructional Materials Specifications for the subjects to be adopted. These specifications outline the courses for which materials are being sought, as well as the standards that those materials are expected to meet. State Instructional Materials Reviewers review and evaluate the materials submitted for adoption. It is the Commissioner of Education who formally adopts the recommendations of the reviewers. The Commissioner may accept the recommendations or amend them. Each county (Local Education Agency) may choose which materials to purchase from the adoption list. Florida schools and school districts must purchase adopted materials through the publisher's Florida depository.
Indiana, US	As of July 2011, all final decisions about the adoption of instructional materials are left entirely to local educational districts. Materials are reviewed and scored against a set rubric supplied by the state education agency. A consensus score is determined for each set of materials and that score is published as a guide for local districts and schools to use in their selection of instructional materials. Before July 2011, the textbook adoption process in Indiana was overseen by the Textbook Advisory Committee (TAC) and the Indiana Department of Education (IDOE). Materials were reviewed for alignment to standards, recommendations provided to the TAC for their consideration, and the State Board of Education provided final approval.
Massachusetts, US	No process for approving textbooks
Minnesota, US	No process for approving textbooks
North Carolina, US	Each year, a call (the Invitation to Submit Textbooks for Evaluation and Adoption in North Carolina) goes to publishers to request submission of textbooks/instructional materials for evaluation. Prior to the call going out, a Curriculum Review Committee is appointed from qualified educators across the state to review relevant curricula and to write the criteria for submission of materials. The criteria are included in the call letter sent to publishers the following April. Evaluation sheets are written using the same criteria. The entire adoption process from this point, throughout the final adoption, stresses compatibility with the Standard Course of Study and the appropriateness of the materials for the teachers and students who are the end users.

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 21: National Policies Regarding Use of Calculators in Mathematics Instruction and Assessment

Reported by National Research Coordinators

Country	Description of the National Policies for Calculator Use in Mathematics Instruction and Assessment
Armenia	No policy
Australia	Statements/policies vary by state. In most cases, calculator use is encouraged but not mandated during mathematics instruction. The National Assessment Program–Literacy and Numeracy has a policy that calculators are not allowed in Years 3 and 5 assessments. Assessment does not take place in Year 4.
Austria	Calculators are not used until grade 5.
Azerbaijan	No policy
Bahrain	No policy
Belgium (Flemish)	Students learn to use the calculator effectively in mathematics instruction.
Botswana	Calculator use is permitted in examinations but not encouraged by teachers.
Chile	No policy
Chinese Taipei	No policy
Croatia	No policy
Czech Republic	No policy
Denmark	Calculator use is permitted in examinations.
England	In Years 3–6 (Grades 2–5), students should be taught to use a calculator for calculations involving several digits (including decimals), and to solve number problems, enter and interpret money calculations and fractions, and select the correct key sequence for calculations with more than one operation. There are statutory examinations at the end of Year 6 (Grade 5) consisting of two test parts; one part allows the use of calculators, the other does not.
Finland	Information and communication technology are to be used to support the student's learning process.
Georgia	No policy
Germany	No national policy. However, in most states, the mathematics curriculum includes basic discretionary statements on the use of calculators (e.g., to check results and to discover mathematics laws).
Honduras	No policy
Hong Kong, SAR	Calculator use aims at facilitating the learning of mathematics rather than replacing mental arithmetic and written calculation. Students can use calculators to explore number patterns, construct concepts, and check different methods and results of problem-solving. The appropriate use of information technology in the teaching and learning of mathematics has become an emphasis in the mathematics curriculum. Calculators are not allowed in the Territory-wide System Assessment for Grades 3 and 6. No public examinations are organized for Grade 4.
Hungary	Calculators are used in instruction to develop cognitive processes.
Iran, Islamic Rep. Of	Calculators are recommended as tools to facilitate and foster skills, such as making or finding patterns. However, students are not allowed to use calculators in mathematics tests in primary school.
Ireland	Calculators are not used prior to Grade 4. The mathematics curriculum provides for the introduction and use of calculators in mathematics from Grade 4 onwards, by which time students should have acquired a mastery of basic number facts and a facility in their use. The curriculum highlights how students' understanding of the structure of number can be enhanced with a calculator through exploration of patterns, sequences, and relationships. The curriculum also encourages the use of calculators to help develop students' problem-solving skills, by allowing them to focus on the structure of a problem and exploring different methods to solve the problem. In addition, the curriculum advises teachers to allow use of calculators for the purpose of checking estimates, performing long and complex computations, and providing exact results to difficult problems. However, the curriculum stipulates that the students need a sound understanding of numbers to make judgments about when it is appropriate to estimate, to calculate mentally, to make a calculation on paper, or to use a calculator for an exact result. Standardized tests for Grade 4 through 6 have specific directions for when a calculator can and cannot be used.
Italy	Calculator use is encouraged from early primary school, to verify the accuracy of calculations worked out mentally or by written algorithms and to explore numerical phenomena.
Japan	No policy
Kazakhstan	According to the mathematics curriculum for Grades 1–4, students carry out calculations with the help of calculators during instruction.
Korea, Rep. of	Students are allowed to use calculators, computers, and other technological and educational tools for complicated calculations during instruction and assessments.
Kuwait	In Grade 4, students are allowed to use calculators to make simple operations in cooperation with the teacher, such as verification of answers. Calculators are not allowed during exams.
Lithuania	Calculator use in primary school is not recommended.
Malta	No reference to calculator use is made in the Grade 5 mathematics curriculum. Calculators are not permissible at this grade level in examinations, but teachers may use them as a teaching and learning tool to assist mathematics understanding and development.
Morocco	No mention of calculator use in the curriculum. In practice, calculators are not used in the classroom; teachers believe students should learn to do operations without calculators.
Netherlands	No policy
New Zealand	Calculator use during instruction and assessment is not specified at this grade at the national level. Schools may specify calculator use in their curricula or policies.

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 21: National Policies Regarding Use of Calculators in Mathematics Instruction and Assessment (Continued)

Country	Description of the National Policies for Calculator Use in Mathematics Instruction and Assessment
Northern Ireland	While the curriculum does not prescribe how mathematics should be taught, including calculator use, statutory assessment arrangements include an expectation that students use a range of mental, written, and calculator methods to solve problems.
Norway	Using digital tools in mathematics involves using such tools for games, exploration, visualization, and publication. It also involves being aware of, using, and evaluating the role of digital tools for problem solving, simulation, and modeling. It also is important to find information, analyze, process, and present data with appropriate tools, and to be critical of sources, analyses, and results.
Oman	The calculator is an important and effective instrument used to develop and reinforce student understanding of mathematics. It is used in teaching number sense, patterns and relationships, and in solving mathematical problems. The curriculum framework includes some statements on how, when, and why to use calculators. During training and visits to schools, teachers are advised on effective use of calculators.
Poland	No policy
Portugal	Calculator use can assist in exploration of number patterns, in mathematical investigations, and in problem solving (in situations where the objective is not the development of calculation ability but other mathematical skills). The calculator should not be used by students to perform calculations that can be done easily using mental calculation strategies.
Qatar	Calculators are introduced in Grade 5.
Romania	No policy
Russian Federation	No policy
Saudi Arabia	No policy
Serbia	Calculators are not allowed during instruction and assessment.
Singapore	Calculators are introduced after Grade 4.
Slovak Republic	Calculator use is recommended for 4th grade students by the national mathematics curriculum. In practice, calculator use is at the discretion of particular teachers or schools.
Slovenia	Calculators are introduced in Grade 6.
Spain	Students are encouraged to get familiar with using calculators to generate series and to compose and break down numbers (units, tens, and hundreds). Calculators may also be used to help solve complex problems.
Sweden	In Grades 1–9, section goals aim to develop student ability to use calculators and computers. Students are not required to use calculators until Grade 5.
Thailand	No policy
Tunisia	No policy
Turkey	Calculator use is allowed in instruction for some objectives in the curriculum.
United Arab Emirates	Calculators are allowed during mathematics classes but not during examinations.
United States	Statements/policies vary by state. Some states have standards for calculator use in instruction and most states have standards for use in assessments. Individual districts may give guidelines regarding calculator use during instructional time. Most states include calculator use in the fourth grade curriculum.
Yemen	Calculator use in Grade 4 assessment is not allowed. This statement is included on examinations.

Benchmarking Participants—Responses Pertain to Benchmarking Provinces/Emirates/States

Alberta Province, Canada	Grade 4 is the first grade in which students are required to use technology in the classroom. When technology is included as a process in a specific learning outcome, that outcome is expected to be both taught and assessed using technology.
Ontario Province, Canada	Although students must develop basic operational skills, calculators and computers can help extend students' capacity to investigate and analyze mathematical concepts and reduce the time otherwise spent on purely mechanical activities. Students can use calculators to perform operations, make graphs, and organize and display data that are lengthier and more complex than those that might be addressed using only pencil-and-paper. Students also can use calculators in various ways to investigate number and graphing patterns, geometric relationships, and different representations, to simulate situations, and to extend problem-solving. When students use calculators in mathematics, they need to know when it is appropriate to apply their mental computation, reasoning, and estimation skills to predict and check answers. There are no statements in the curriculum regarding the use of calculators in Grade 4 classroom testing.
Quebec Province, Canada	The use of information and communications technologies is compulsory, though activities involving ICT are at teacher discretion.
Abu Dhabi, UAE	There are no specific policy statements concerning calculators in Grade 4, but in practice they are not used in public schools. Using calculators on standardized tests is not allowed.
Dubai, UAE	No overall policy is specified, varies by school type
Florida, US	No policy
North Carolina, US	Beginning in Grade 3, students should develop flexibility in solving problems by selecting strategies and using mental computation, estimation, calculators or computers, and paper and pencil. The end-of-grade test for Grade 4 consists of two parts; students can use calculators on one part, but not on the other.

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 22: National Policies Regarding Use of Calculators in Mathematics Instruction and Assessment

Reported by National Research Coordinators

Country	Description of the National Policies for Calculator Use in Mathematics Instruction and Assessment
Armenia	Calculators may be used only for simple calculations in instruction and assessment.
Australia	Statements/policies vary by state. In most cases, calculator use is encouraged but not mandated during mathematics instruction. At Year 8, teachers are expected to determine the most appropriate method of assessing student learning. Where the curriculum suggests calculator use is part of the learning outcomes, teachers may determine appropriate calculator use. Where calculator use is mandated in the curriculum, in general, use in assessment would be expected.
Bahrain	Calculators are allowed during instruction and assessment.
Botswana	One of the aims of the Junior Secondary Mathematics program is for all children to develop the ability to use calculators. The use of calculators is permitted for assessments.
Chile	No policy
Chinese Taipei	Calculator use is not allowed on formal tests, especially the required senior high school entrance examination. Therefore, calculators are not used in the classroom in Grade 8.
England	In Key Stage 3 (Years 7–9, Grades 6–8) students should be able to calculate accurately, selecting mental methods or calculating devices as appropriate.
Finland	Information and communication technology are to be used to support the students' learning process. Within the "Numbers and Calculations" content domain for Grades 6–9, calculator use is mentioned in the curriculum.
Georgia	No policy
Ghana	The syllabus is designed to help the student to use the calculator and the computer for problem solving and investigation of real life situations. The syllabus is silent on the use of calculators for tests and examinations.
Honduras	The curriculum prescribes the use of technology for teaching some topics.
Hong Kong SAR	Calculator use aims at facilitating the learning of mathematics rather than replacing mental arithmetic and written calculation. Students can use calculators for data analysis, simulation, graphical presentation, symbolic manipulation, and observing patterns. The appropriate use of information technology in the teaching and learning of mathematics has become an emphasis in the mathematics curriculum. The Hong Kong Examination and Assessment Authority permits calculator use in the Territory-wide System Assessment at Grade 9 and in the Hong Kong Diploma of Secondary Education Examination at Grade 12.
Hungary	Calculators are used in instruction to develop cognitive processes.
Indonesia	No policy
Iran, Islamic Rep. of	Calculators are recommended as tools to facilitate and foster skills. Calculators are not allowed in examinations.
Israel	No policy
Italy	Calculator use is encouraged from early primary school, to verify the accuracy of calculations worked out mentally or by written algorithms and to explore numerical phenomena. Calculator use is forbidden during the national exam at the end of Grade 8. Calculator use is generally allowed during classroom tests, at teachers' discretion.
Japan	In teaching each content area, consideration should be given to properly using tools like the soroban (Japanese abacus), calculators, computers, and information and communication networks in order to improve the learning results. This should especially be taken into account for the instructional content related to numerical calculations, as well as in teaching through activities such as observation, manipulation, and experimentation.
Jordan	Policy aims to integrate ICT in mathematics instruction, and teachers should use calculators to facilitate students' learning. Calculators may be used in assessment, unless the assessment objective is to measure student ability in performing mathematical operations (without calculators), such as addition, subtraction, etc.
Kazakhstan	In instruction, calculators may be used in numerical calculations (particularly those involving long numbers), including approximation or multiplication.
Korea, Rep. of	Calculators and computers should be used to help understand mathematical concepts, principles, and rules, and increase problem solving ability, except when the enhancement of calculation ability is not the ultimate educational objective.
Lebanon	Only non-programmable calculators are permitted in instruction and examination.
Lithuania	Students can use calculators when taking examinations at the end of basic school (Grade 10) and at the end of the secondary school (Grade 12).
Macedonia, Rep. of	No policy
Malaysia	Calculators are allowed during mathematics instruction and examinations.
Morocco	The national curriculum states that, at this level, students should be encouraged to use calculators efficiently when learning mathematics. The curriculum also describes how they should be used by students and teachers, though it does not refer to calculator use during quizzes and tests. However, students are allowed to use non-programmable calculators during tests and exams.
New Zealand	Calculator use during instruction and assessment is not specified at this grade at the national level. Schools may specify calculator use in their curricula or policies.
Norway	Using digital tools in mathematics involves using such tools for games, exploration, visualization, and publication. It also involves knowing about, using, and evaluating the role of digital tools for problem solving, simulation, and modeling. It is important to find information, analyze, process, and present data with appropriate tools, and to be critical of sources, analyses, and results. During the Grade 10 mathematics examination, students are allowed to use calculators or other aids on just one part of the exam.
Oman	The calculator is an important and effective instrument used to develop and reinforce students' understanding of mathematics. Students can use calculators in mathematics tests, but only to solve non-algorithmic problems.

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 22: National Policies Regarding Use of Calculators in Mathematics Instruction and Assessment (Continued)

Country	Description of the National Policies for Calculator Use in Mathematics Instruction and Assessment
Palestinian Nat'l Auth.	Students may use calculators for solving numeric problems and checking the correct answers for problems with numbers of more than 4 digits. Calculator use on tests is not formally allowed.
Qatar	Calculators are used for specified curricular goals.
Romania	No policy
Russian Federation	The requirements for graduation from basic school include using acquired knowledge and skills in practice and everyday life to solve simple practical computing tasks with reference materials, calculators, or computers when necessary.
Saudi Arabia	Calculators are allowed for all purposes. Sometimes teachers give students calculators for specific instruction to help them understand specific skills.
Singapore	One aim in mathematics education is to enable students to make effective use of a variety of mathematical tools, including information and communication technology tools, in the learning and application of mathematics. Calculator use at the upper secondary level does not take away the importance of mental and manual calculations; these skills are still important because students need to have good number sense and estimation skills to check the reasonableness of answers obtained using calculators. Schools should continue to emphasize mental and manual calculations at the lower secondary level, if considered necessary for their students. There is flexibility to include non-calculator sections in school-based assessment at these levels. At Secondary 4 (Grade 10), national examinations allow and require the use of calculators.
Slovenia	Calculators should be used to help students calculate using larger numbers when appropriate, and are not introduced before Grade 6. The main focus of learning mathematics should remain mental calculations, mathematical thinking, and understanding of methods where calculators are not a major necessity.
South Africa	Students are encouraged to sharpen their ability to estimate and judge the reasonableness of solutions using a variety of strategies, including calculators. However, in practice, schools do not have calculators.
Sweden	In Grades 1–9, section goals aim to develop student ability to use calculators and computers. From Grade 5, students are required to be able to use calculators.
Syrian Arab Republic	It is forbidden to use calculators on exams because mental arithmetic keeps student intellect active. Students should not depend on calculators when answering and solving many mathematical problems involving addition, subtraction, division, and multiplication. Most students and schools do not have calculators.
Thailand	No policy
Tunisia	The use of calculators is permitted to solve simple problems or mathematical operations in instruction.
Turkey	Calculator use is allowed in instruction for some objectives in the curriculum.
Ukraine	No policy
United Arab Emirates	Calculators are allowed during mathematics classes but not during examinations.
United States	Statements/policies vary by state. Some states have standards for calculator use in instruction and most states have standards for use in assessments. Individual districts may give guidelines regarding calculator use during instructional time. Most states include calculator use in the eighth grade curriculum.

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 22: National Policies Regarding Use of Calculators in Mathematics Instruction and Assessment (Continued)

Country	Description of the National Policies for Calculator Use in Mathematics Instruction and Assessment
Benchmarking Participants—Responses Pertain to Benchmarking Provinces/Emirates/States	
Alberta, Canada	The use of technology is one of the processes required to be used in the teaching and learning of mathematics. When technology is included as a process in a specific learning outcome, that outcome is expected to be both taught and assessed using technology.
Ontario, Canada	Although students must develop basic operational skills, calculators and computers can help extend student capacity to investigate and analyze mathematical concepts and reduce the time otherwise spent on purely mechanical activities. Students can use calculators or computers to perform operations, make graphs, and organize and display data that are lengthier and more complex than those that might be addressed using only pencil-and-paper. Students also can use calculators in various ways to investigate number and graphing patterns, geometric relationships, and different representations, to simulate situations, and to extend problem-solving. When students use calculators and computers in mathematics, they need to know when it is appropriate to apply their mental computation, reasoning, and estimation skills to predict and check answers. There are no statements in the curriculum regarding the use of calculators in Grade 8 classroom testing.
Quebec, Canada	The use of information and communications technologies is compulsory, though activities involving ICT are at teacher discretion.
Abu Dhabi, UAE	Calculators are permitted but not required.
Dubai, UAE	No overall policy is specified, varies by school type
Alabama, US	The standards contain excerpts from the National Council of Teachers of Mathematics which includes a technology principle: "Appropriate use of technology is essential for teaching and learning." Students are allowed to have access to a simple calculator during part of the Grade 8 state mathematics assessment, but it is not necessary.
California, US	Technology should be used to promote mathematical learning. Technology can help support students' understanding of mathematical concepts, quantitative reasoning, and achievement when used as a tool for solving problems, testing conjectures, accessing data, and verifying solutions. As the Common Core State Standards for mathematics are implemented, students are expected to use technology, including calculators, to solve mathematical and real-world problems. The use of calculators is not allowed on statewide mathematics assessments.
Colorado, US	The standards list that students should be able to link concepts and procedures as they develop and use computational techniques, including estimation, mental arithmetic, paper-and-pencil, calculators, and computers, in problem-solving situations and communicate the reasoning used in solving these problems. Students should be able to solve simple linear equations in problem-solving situations using a variety of methods (informal, formal, graphical) and a variety of tools (physical materials, calculators, computers).
Connecticut, US	There are content standards at Grades 6 and 8 that provide the expectation that students will use calculators to solve specific types of problems. For the mathematics state assessment, calculator use is allowed on some portions of the test but not others.
Florida, US	No policy for instruction. In Grades 7 and 8, use of a simple calculator is allowed on the state assessments.
Indiana, US	The standards contain excerpts from the National Council of Teachers of Mathematics which includes a technology principle: "Calculators and computers are reshaping the mathematics landscape, and school mathematics should reflect those changes. Students can learn more mathematics more deeply with the appropriate and responsible use of technology." Students in Grades 6-8 are allowed to use a calculator on the Applied Skills Assessment and on one part of the Multiple-Choice Assessment. The memory and stored programs and applications in each personal calculator should be cleared before and after testing.
Massachusetts, US	Technology enhances the mathematics curriculum in many ways. Tools such as graphing calculators and computers with appropriate software, if properly used, contribute to a rich learning environment for developing and applying mathematical concepts. However, appropriate use of calculators is essential; calculators should not be used as a replacement for basic understanding and skills. Although the use of a graphing calculator can help middle and secondary students to visualize properties of functions and their graphs, graphing calculators should be used to enhance their understanding and skills rather than replace them. Calculators are allowed on one of two sections of the Grade 8 state-wide assessment.
Minnesota, US	Minnesota state law requires that technology be 'appropriately' embedded into the standards and benchmarks of all disciplines. Students may use a calculator on some parts of the state assessment, but not on others.
North Carolina, US	Beginning in Grade 3, students should develop flexibility in solving problems by selecting strategies and using mental computation, estimation, calculators or computers, and paper and pencil. Students are allowed to have access to a calculator during the Grade 8 mathematics examination.

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 23: National Policies Regarding Use of Computers in Mathematics and Science Instruction

Reported by National Research Coordinators

Country	Description of the National Policies for Computer Use	
	Mathematics Instruction	Science Instruction
Armenia	No policy	No policy
Australia	Statements/policies vary by state. In most cases, computer use is encouraged but not mandated.	Same
Austria	No policy	No policy
Azerbaijan	No policy	No policy
Bahrain	The general teaching objectives state that different learning sources (including information technology) should be used to enhance communication skills and continuous personal learning.	Same
Belgium (Flemish)	The Flemish government has formulated attainment targets for ICT. Schools have been obliged to meet these extra-curricular attainment targets since September 1, 2007.	Same
Botswana	The environmental science and mathematics syllabi encourage the use of technology. The aims of the Primary Education Program include an awareness and appreciation of the use of computers in everyday life. However, few schools have computers available for Grade 4 students.	Same
Chile	No policy	No policy
Chinese Taipei	No policy	The science curricula contain statements suggesting that teachers encourage students to use computers to search for information, manage information collection, and arrange the data collected.
Croatia	No policy	No policy
Czech Republic	No policy	No policy
Denmark	The curriculum contains minimal mention on the use of computers.	No policy
England	Students should be given opportunities to apply and develop their ICT capability through the use of ICT tools to support their learning in all subjects.	Same
Finland	The learning environment must provide opportunities to support student development as a member of today's information society through the use of computers, other media technology, and data networks.	No policy
Georgia	No policy	No policy
Germany	No national policy. However, in most states, the mathematics curriculum includes basic discretionary statements on the use of computers in obtaining information from different media and computer-based learning (e.g., geometrical software and learning software).	No national policy. However, in most states, the science curriculum includes a statement on the use of computers in obtaining information from different media, learning how to design things using media, and computer-based learning.
Honduras	No policy	No policy
Hong Kong, SAR	Teachers should fully utilize various types of software to design diversified teaching activities for students to engage in self- and collaborative study. Students should be guided in appropriate use of software to improve their learning.	In the science curriculum, the strand "Global Understanding and the Information Era" includes learning elements on use of computers.
Hungary	Computers are used in instruction to develop cognitive processes.	No policy
Iran, Islamic Rep. Of	No policy	No policy
Ireland	The mathematics curriculum includes general statements on the use of ICT in primary school. For example, mathematics education should enable students to recognize situations where mathematics can be applied, and use appropriate technology to support such applications. The curriculum notes that computers should not replace good teaching and extensive use of manipulatives.	The science curriculum includes general statements on the use of ICT in primary school, noting that students' investigations and explorations can be enhanced through the use of ICT, such as: recording and analyzing information, simulating investigations and tests that support scientific topics, communicating scientific information and findings, working collaboratively on science projects with students in other schools, and in accessing and using a range of scientific and technological information. It notes that computer-based simulation may be particularly helpful when students are conducting investigations difficult to organize in real-life contexts.
Italy	Computer use is encouraged from early primary school to verify the accuracy of calculations worked out mentally or by written algorithms and to explore numerical phenomena.	No policy

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 23: National Policies Regarding Use of Computers in Mathematics and Science Instruction (Continued)

Country	Description of the National Policies for Computer Use	
	Mathematics Instruction	Science Instruction
Japan	It is necessary to appropriately use computers in order to enrich student learning.	Computers and audio-visual aids should be used appropriately in giving instructions on observations, experiments, cultivation, raising animals, and making learning materials.
Kazakhstan	Students are trained to use computers and new technologies.	Same
Korea, Rep. of	Computers should be used to understand mathematical concepts, principles, and rules, and to increase problem solving ability, except when the enhancement of calculation ability is the ultimate educational objective.	Students should appropriately use computer-assisted laboratories, the Internet, multimedia, etc.
Kuwait	The curriculum does not include information about computer training, but interested technical supervisors and school teachers can use available programs for teaching lessons. There also are some integrated lessons, introduced by computer teachers, that aim at training students to use computers. Students are assigned some activities using computers.	Same
Lithuania	A compulsory IT course starts from Grade 5. In primary schools, teachers may use computers at their discretion.	Same
Malta	The Year 5 (Grade 5) syllabus states that computer software available in the classroom should enhance, reinforce, and consolidate learning outcomes. Mathematics software is available in all classrooms, together with interactive whiteboards. ICT can provide children with opportunities to learn from feedback, observe patterns, see connections, work with dynamic images, explore data, and input simple instructions.	Information technology plays a key role in the scientific process and the teaching of science. Students can be encouraged to engage with science to find information through multimedia resources.
Morocco	To improve the quality of teaching and learning through the use of ICT in all public schools, Moroccan schools have been equipped with computer labs with ADSL Internet access, and teachers, headmasters, advisors, and inspectors have been provided with ICT training.	Same
The Netherlands	Computers are not mentioned in the core objectives. However, computers are used on a large scale for teaching and learning in Dutch primary schools.	Same
New Zealand	National policy includes a statement on the use of ICT to support effective pedagogy; schools are encouraged to explore ways ICT can enhance teaching and learning.	Same
Northern Ireland	While the curriculum does not prescribe how mathematics should be taught, including computer use, schools have been provided with ICT equipment and resources, and ICT is increasingly used as an integral part of teaching and learning. The statutory curriculum and assessment arrangements for numeracy require students to be able to collect, classify, record, and present data drawn from a range of meaningful situations, using graphs, tables, diagrams, and ICT software, enter information in a database or spreadsheet and interpret the results, use a programing language to create pictures and patterns, and generate shapes.	While the curriculum does not prescribe how science should be taught, including computer use, schools have been provided with ICT equipment and resources, and ICT is increasingly used as an integral part of teaching and learning.
Norway	Using digital tools in mathematics involves using such tools for games, exploration, visualization, and publication. It also involves being aware of, using, and evaluating the role of digital tools for problem solving, simulation, and modeling. It also is important to find information, analyze, process, and present data with appropriate tools, and to be critical of sources, analyses, and results.	Using digital tools in natural science for exploration, measurement, visualization, simulation, registration, documentation, and publication when performing experiments and fieldwork. Digital animations, simulations, and games are good aids for stimulating creativity, and demonstrating and visualizing natural science problems and research questions. Critical assessment of Internet-based information reinforces work in this subject. Digital communication systems make discussing natural science problems and research questions possible.
Oman	Students use computers to explore and move from abstract to concrete mathematical concepts. Certain programs provide activities that reinforce mathematical concepts already learned in the classroom.	Students use computers as a resource for scientific inquiry and the application of scientific knowledge.
Poland	No policy	No policy
Portugal	The use of new information and communication technologies are recommended in learning geometry.	The use of new information and communication technologies are recommended for the research of scientific information.
Qatar	ICT is integrated into the standards.	Same

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 23: National Policies Regarding Use of Computers in Mathematics and Science Instruction (Continued)

Country	Description of the National Policies for Computer Use	
	Mathematics Instruction	Science Instruction
Romania	No policy	No policy
Russian Federation	No policy	No policy
Saudi Arabia	No policy	No policy
Serbia	No policy	No policy
Singapore	Teachers and students should harness technology in the teaching and learning of mathematics. There are many software programs and tools that teachers can use to enhance the teaching and learning of mathematics. Basic word processing and spreadsheet skills support student problem-solving strategies and activities. Technology also can be used to motivate and empower students.	Schools are guided by the Ministry of Education's Master plan for ICT in Education.
Slovak Republic	No policy	No policy
Slovenia	ICT is widely used. In schools, students mostly use computers in computer laboratories which are available in most schools. The Ministry offers many teacher development programs for the use of ICT. Students in Grade 6 and higher are expected by most teachers to know and use computers for their homework for different subjects. In the mathematics curriculum, it is expected that students learn how to use a computer outside mathematics lessons. Computers should be used in mathematics only to learn how to work with spreadsheets in Grades 6–9. Teachers may choose to use a computer in a classroom or in a computer lab to demonstrate mathematics content. The curriculum recommends the use of special software for learning mathematics, but does not require it.	ICT is widely used. Students mostly use computers in computer laboratories which are available in most schools. The Ministry offers many teacher development programs for the use of ICT. Students in Grade 6 and higher are expected by most teachers to know and use computers for their homework for different subjects.
Spain	No policy	In Grades 1 and 2, under "Objects, equipment, and technology," students learn the basic components of computers, including use and care of computer resources. In Grades 3 and 4, under "Basic use of word processors," students learn to add headlines, format, save and open files, changes and modifications, and print. Finding information on the web and submitting assignments digitally also is encouraged.
Sweden	In Grades 1–9, section goals aim to develop students' ability to use calculators and computers.	No policy
Thailand	No policy	No policy
Tunisia	Compact discs are provided with textbooks.	Same
Turkey	Computer usage is a part of information technology usage skills in the curriculum.	The new science curriculum puts more emphasis on using computers in science education.
United Arab Emirates	Mathematics and science teachers in public schools use computers in their classrooms in Grades 4–8 for demonstration and enrichment purposes, to introduce facts and information to the students, and to enable students to do virtual experiments.	Same
United States	The United States does not have a national curriculum. Some states have standards for computer use in instruction and as part of technology literacy for students. Individual districts may give guidelines regarding computer use during instructional time.	Most states do not have policies regarding computer use. However, many states have standards for technology literacy (either separate standards or integrated science standards) requiring computer use in science instruction. For example, some science standards and local curricula include mastery of spreadsheet or database software as necessary for data analysis.
Yemen	No policy	No policy

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 23: National Policies Regarding Use of Computers in Mathematics and Science Instruction (Continued)

Country	Description of the National Policies for Computer Use: Mathematics Instruction	Description of the National Policies for Computer Use: Science Instruction
Benchmarking Participants—Responses Pertain to Benchmarking Provinces/Emirates/States		
Alberta, Canada	The use of technology is one of the processes required in the teaching and learning of mathematics; Grade 4 is the first grade in which students are required to use technology.	Students should access information from library, classroom, community, and computer-based resources. Students should be able to record observations and measurements accurately using captioned pictures and charts, with guidance in their construction. Computer resources may be used for record-keeping and for display and interpretation of data.
Ontario, Canada	Although students must develop basic operational skills, calculators and computers can help extend students' capacity to investigate and analyze mathematical concepts and reduce the time otherwise spent on purely mechanical activities. Students are asked to select and use a variety of concrete, visual, and electronic learning tools and appropriate computational strategies to investigate mathematical ideas and to solve problems.	Information and communications technologies (ICT) provide a range of tools that can significantly extend and enrich teachers' instructional strategies and support students' learning in science and technology. Computer programs can help students collect, organize, and sort the data they gather and to write, edit, and present reports on their findings. ICT also can be used to connect students to other schools, at home and abroad, and to bring the global community into the local classroom. Technology also enables simulations when field studies on a particular topic are not feasible. Whenever appropriate, therefore, students should be encouraged to use ICT to support and communicate their learning.
Quebec, Canada	The use of information and communications technologies is compulsory, though activities involving ICT are at teacher discretion.	Same
Abu Dhabi, UAE	Students who participated in TIMSS 2011 did not have computers as part of instruction in Grade 4, according to then-existing policy. Since September 2011, students in public schools in Grade 4 will study an integrated curriculum that integrates computer use into Grade 4 instruction.	Same
Dubai, UAE	No overall policy is specified, varies by school type	Same
Florida, US	No policy	No policy
North Carolina, US	Beginning in Grade 3, students should develop flexibility in solving problems by selecting strategies and using mental computation, estimation, calculators or computers, and paper and pencil.	Some standards of technology literacy call for the use of computers in science instruction. For example, some science standards and local curricula include mastery of spreadsheet or database software as necessary for data analysis.

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 24: National Policies Regarding Use of Computers in Mathematics and Science Instruction

Reported by National Research Coordinators

Country	Description of the National Policies for Computer Use	
	Mathematics Instruction	Science Instruction
Armenia	No policy	No policy
Australia	Statements/policies vary by state. In most cases computer use is encouraged but not mandated.	Same
Bahrain	According to the Mathematics Objectives, computers are used for teaching statistics.	Information Technology and other different sources of knowledge are used to enhance communication and continuous personal learning.
Botswana	The science and mathematics syllabi encourage the use of technology . The aims of the three-year integrated science and mathematics program include developing basic computer skills and understanding the significance of computers in the study of science, and developing awareness of computer applications in mathematics activities. Computers are generally introduced to students in Grade 8.	Same
Chile	No policy	No policy
Chinese Taipei	Some teachers use PowerPoint, Flash, GSP, Cabri, or GeoGebra in their teaching, especially in geometry class.	For Grades 7–9, curriculum guidelines for the application of technology and information include the following: learning to use the computer and the Internet to collect and process information, making reports, learning to solve problems of everyday life through the application of science and technology, having a basic understanding of computer hardware and software and their uses, and learning to use the computer and its peripherals for information communication and transmission.
England	Students should be given opportunities to apply and develop their Information & Communication Technology (ICT) capability through the use of ICT tools to support their learning in all subjects. Students should be given opportunities to support their work by being taught to do the following: find things out from a variety of sources; select and synthesize information to meet their needs and develop an ability to question its accuracy, bias, and plausibility; develop their ideas using ICT tools to amend and refine their work and enhance its quality and accuracy; exchange and share information, both directly and through electronic media; and review, modify, and evaluate their work, reflecting critically on its quality, as it progresses.	Same. In addition, students should be able to obtain, record, and analyze data from a wide range of primary and secondary sources, including ICT sources, and use their findings to provide evidence for scientific explanations. They should also be able to use appropriate methods, including ICT, to communicate scientific information and contribute to presentations and discussions about scientific issues.
Finland	The learning environment must provide opportunities to support student development as a member of today's information society through the use of computers, other media technology, and data networks.	Students will learn to use research methods typical for acquiring scientific knowledge, including ICT, and will learn to evaluate the reliability and importance of the information.
Georgia	ICT is a stand-alone discipline in the National Curriculum. ICT curriculum contains statements about the use of computing devices as cross-curricular competencies.	Same
Ghana	The syllabus is designed to help students use calculators and computers for problem solving and investigation of real life situations.	The syllabus is designed to help students use calculators and computers to solve real life challenges. Students are expected to use the Internet to research information for assignments and projects where computers are available. CD's with games/simulations of science events also are available, and teachers are free to use them in instruction.
Honduras	Technology is used for certain topics.	Same
Hong Kong SAR	The popularity of graphing calculators, the availability of computers and other information technology (IT) aids in the classrooms will have an impact on the mathematics curriculum in terms of content and strategy for mathematics teaching and learning. There are ranges of ways in which IT may be used in mathematics classes, including data analysis, simulation, graphical presentation, symbolic manipulation, and observing patterns. The appropriate use of IT in mathematics teaching and learning has become an emphasis in the mathematics curriculum.	IT for Interactive Learning in Science is advocated. Using IT allows space for developing student scientific thinking, creativity, and problem-solving skills. Teachers should exercise professional judgment in the appropriate use of IT and ensure that the students are provided with sufficient opportunity for hands-on experiments to develop their science processing skills.
Hungary	Computers are used in instruction to develop cognitive processes.	Same
Indonesia	No policy	No policy
Iran, Islamic Rep. of	Computer use is recommended, but at teacher and school discretion.	Same

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 24: National Policies Regarding Use of Computers in Mathematics and Science Instruction (Continued)

Country	Description of the National Policies for Computer Use	
	Mathematics Instruction	Science Instruction
Israel	The current curriculum contains only general statements advocating the use of computers in the different processes of learning, both in Algebra and Geometry.	The current curriculum contains only general statements advocating the integration of computers in instruction. Students acquire skills related to the use of digital sources of information and learn to use computer tools to carry out scientific research.
Italy	Computer use is encouraged from early primary school to verify the accuracy of calculations worked out mentally or by written algorithms and to explore numerical phenomena.	No policy
Japan	In teaching each content area, consideration should be given to properly using tools like the soroban (Japanese abacus), calculators, computers, and information and communication networks in order to improve learning results. This should especially be taken into account for the instructional content related to numerical calculations, as well as in teaching through activities like observation, manipulation, and experimentation.	For the instruction in each field, consideration should be given to ensure the proactive and appropriate use of tools, including computers and information and communication networks, in areas such as searching for information in the course of observations and experiments, conducting experiments, data processing, and experimental measurements.
Jordan	Students should be able to define, formulate, and represent linear functions using computers and calculators to investigate function properties.	Teachers should use computers in teaching.
Kazakhstan	Students are trained to use computers and new technologies.	Same
Korea, Rep. of	Computers should be used to understand mathematical concepts, principles, and rules, and increase problem solving ability, except when the enhancement of calculation ability is the ultimate educational objective.	Students should appropriately use computer-assisted laboratories, the Internet, and multimedia.
Lebanon	No policy	No policy
Lithuania	There is a compulsory IT course for Grades 5–6. Grades 7–8 have integrated lessons that include IT together with various other subjects. Each school chooses these integrated subjects.	Same
Macedonia, Rep. of	As of 2010, the Bureau for Development of Education recommended using computers in 30% of instruction.	Same
Malaysia	No policy	No policy
Morocco	The curriculum encourages the use of computers in teaching mathematics throughout secondary school. There is still a need for reinforcing the use of computers and teacher training in Grade 8.	The curriculum does not refer to using computers, but teachers are encouraged to use computers in the classroom. A new program (GENIE) is specifically designed to equip schools with computers and increase their use in the classroom.
New Zealand	National policy includes a statement on the use of ICT to support effective pedagogy; schools are encouraged to explore ways ICT can enhance teaching and learning.	Same
Norway	Digital tools are used in mathematics for games, exploration, visualization, and publication. The curriculum for digital skill involves being aware of, using, and evaluating the role of digital tools for problem solving, simulation, and modeling. It also is important to find information, analyze, process, and present data with appropriate tools, and to be critical of sources, analyses, and results. There are specific curricular goals in Grades 7 and 10.	Digital tools are used in science for exploration, measurement, visualization, simulation, registration, documentation, and publication when performing experiments and fieldwork. Digital animations, simulations, and games are good aids for stimulating creativity, and demonstrating and visualizing natural science problems and research questions. Critical assessment of Internet-based information reinforces the work in this subject. Digital communication systems make it possible to discuss natural science problems and research questions. There are specific curricular goals in Grades 7 and 10.
Oman	Computers should be used only as a source of teaching to help students discover and transition from abstract to concrete mathematical concepts.	Students use computers as a resource for doing certain activities in the science syllabus, with scope and sequence defining how and when students use them.
Palestinian Nat'l Auth.	Computer software is used for data manipulation (e.g., Excel) and for content demonstration (e.g., PowerPoint). The Internet is used as a source of information. Some teachers require computer use, but there is no obligatory policy in this regard.	Same
Qatar	ICT is integrated into the curricular goals.	Same
Romania	No policy	No policy

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 24: National Policies Regarding Use of Computers in Mathematics and Science Instruction (Continued)

Country	Description of the National Policies for Computer Use	
	Mathematics Instruction	Science Instruction
Russian Federation	Students are expected to use their acquired knowledge and skills in practice and everyday life to solve simple practical computing tasks with calculators, computers, or other reference materials when necessary.	No policy
Saudi Arabia	Students are sometimes asked to visit certain websites or links.	Same
Singapore	IT tools and calculators are necessary in mathematics teaching and learning. They can extend the range of problems accessible to students, connect mathematics with the real world, enable quick and accurate computations, and make connections between numerical, graphical and symbolic representations, and between algebraic and geometric ideas. In particular, IT can facilitate conceptual understanding, research, investigation, communication, reflection, and collaboration. The integration of IT into the teaching and learning of mathematics can help develop and motivate student interest in the subject, enrich their learning experience, and spur them to learn independently.	Schools are guided by the Ministry of Education's Master Plan for ICT in Education.
Slovenia	Computers should be used in mathematics lessons so that students learn to use data tables (e.g., Excel). Teachers may decide how to use a computer in the classroom; for example, using mathematical didactic programs for drawing geometry or learning computational skills.	Computers should be used in computer labs during science lessons. Teachers may decide how to use a computer in the classroom; for example, using scientific didactical programs or learning computational skills).
South Africa	Computers provide opportunities for students to use technology to engage with the historical and cultural developments of numerical counting and writing systems. However, many students have no computer access.	No policy
Sweden	In Grades 1–9, section goals aim to develop students' ability to use calculators and computers.	No policy
Syrian Arab Republic	No policy	No policy
Thailand	No policy	No policy
Tunisia	The national curriculum encourages computer use whenever possible in the teaching of algebra and geometry. However, the curriculum contains no specific content for or recommended uses of computers.	No policy
Turkey	Computer use is a part of information technology usage skills in the curriculum.	The new science curriculum puts more emphasis on using computers in science education.
Ukraine	The national curriculum contains no instruction about student computer use, but teachers use computers in instruction.	Same
United Arab Emirates	Mathematics and science teachers in public schools use computers in their classrooms in Grades 4–8 for demonstration and enrichment purposes, to introduce facts and information to the students, and to enable students to do virtual experiments. At the eighth grade, teachers also use computers to access additional supporting materials from educational sites corresponding to their textbooks.	Same
United States	The United States does not have a national curriculum. Some states have standards for computer use in instruction and as part of technology literacy for students. Individual districts may give guidelines regarding computer use during instructional time.	Most states do not have policies regarding computer use. However, many states have standards for technology literacy (either as separate standards or integrated in science standards) requiring computer use in science instruction. For example, some science standards and local curricula include mastery of spreadsheet or database software as necessary for data analysis.

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 24: National Policies Regarding Use of Computers in Mathematics and Science Instruction (Continued)

Country	Description of the National Policies for Computer Use	
	Mathematics Instruction	Science Instruction
Benchmarking Participants—Responses Pertain to Benchmarking Provinces/Emirates/States		
Alberta, Canada	The use of technology is one of the processes required in the teaching and learning of mathematics. When technology is included as a process in the specific outcome, that outcome is expected to be both taught and assessed using technology.	Students will compile and display data, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, bar graphs, and line graphs.
Ontario, Canada	Although students must develop basic operational skills, calculators and computers can help extend student capacity to investigate and analyze mathematical concepts and reduce the time otherwise spent on purely mechanical activities. Students are asked to select and use a variety of concrete, visual, and electronic learning tools and appropriate computational strategies to investigate mathematical ideas and to solve problems.	Information and communications technologies (ICT) provide a range of tools that can significantly extend and enrich teachers' instructional strategies and support students' learning in science and technology. Computer programs can help students collect, organize, and sort the data they gather and to write, edit, and present reports on their findings. ICT also can be used to connect students to other schools, at home and abroad, and to bring the global community into the local classroom. Technology also enables simulations when field studies on a particular topic are not feasible. Whenever appropriate, therefore, students should be encouraged to use ICT to support and communicate their learning.
Quebec, Canada	The use of information and communications technologies is compulsory, though activities involving ICT are at teacher discretion.	Same
Abu Dhabi, UAE	Computers are allowed in mathematics instruction.	As of September 2011, the science teaching and learning curriculum includes the use of computers in science classes.
Dubai, UAE	No overall policy is specified, varies by school type	Same
Alabama, US	No policy	In the science course of study there is a position statement for all grades supporting the use of technology whenever feasible and it also states that students should be engaged in considering positive and negative consequences of the design and use of technology.
California, US	As the Common Core State Standards for Mathematics are implemented, students are expected to use a variety of technologies to solve mathematical and real-world problems. The 1997 Mathematics Content Standards for California Public Schools states, "Computer-based geometry construction tools allow students to see figures in three-dimensional space and experiment with the effects of transformations." Also noted are the use of spreadsheet and database programs for compiling and displaying data to make and test conjectures, the Internet to exchange ideas and test hypotheses, and technology ". . . to reinforce basic skills through computer-assisted instruction, tutoring systems, and drill-and-practice software."	No policy
Colorado, US	The standards list that students should be able to link concepts and procedures as they develop and use computational techniques, including estimation, mental arithmetic, paper and pencil, calculators, and computers, in problem-solving situations and communicate the reasoning used in solving these problems. Students should be able to solve simple linear equations in problem-solving situations using a variety of methods (informal, formal, and graphical) and a variety of tools (physical materials, calculators, and computers).	Students are expected to conduct experiments using tools and technology including computers.
Connecticut, US	No policy	No policy
Florida, US	No policy	No policy
Indiana, US	Calculators and computers are reshaping the mathematics landscape, and school mathematics should reflect those changes. Students can learn more mathematics more deeply with the appropriate and responsible use of technology.	The academic standards state that students should use computers to organize and compare information. Students should use computers to store and retrieve information in topical, alphabetical, numerical, and keyword files and create simple files of students' own devising.
Massachusetts, US	Tools such as computers with appropriate software, if properly used, contribute to a rich learning environment for developing and applying mathematical concepts.	No policy
Minnesota, US	Minnesota state law requires that technology be 'appropriately' embedded into the standards and benchmarks of all disciplines.	No policy
North Carolina, US	Beginning in Grade 3, students should develop flexibility in solving problems by selecting strategies and using mental computation, estimation, calculators or computers, and paper and pencil.	The course of study provides some suggestions for using personal computers to analyze data, but there are no formal policies.

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 25: Main Preparation Route and Current Requirements for Fourth Grade Teachers

Reported by National Research Coordinators

Country	Main Teacher Preparation Route	Current Requirements: Supervised Practicum During Teacher Education Program	Current Requirements: Passing a Qualifying Examination (e.g., licensing, certification)	Current Requirements: Completion of Probationary Teaching Period	Current Requirements: Completion of Mentoring or Induction Program
Armenia	Most teachers receive their education through a university degree program.	●	●	●	●
Australia	Most teachers receive a 4-year university degree in education, or complete a 1–2 year postgraduate qualification program following a 4-year non-education degree.	●	○	●	○
Austria	Teachers receive a bachelor's degree from a 6-semester education at University Colleges of Teacher Education.	●	●	○	○
Azerbaijan	Most teachers receive their education through a university degree program.	●	●	○	●
Bahrain	Most teachers have a Bachelor's of Education from the College of Education or a post-graduate diploma in education following a non-education degree.	○	○	○	●
Belgium (Flemish)	Teacher training includes a 3-year college program for primary school teachers. Continuing teacher-training courses allow the acquisition of particular qualifications.	●	●	○	○
Botswana	Teachers obtain a Diploma in Primary Education from colleges of education.	●	●	●	○
Chile	Most teachers receive their education through a university degree program, although some attend professional institute programs (no bachelor's degree).	●	○	○	○
Chinese Taipei	Most teachers receive their education through a university degree program.	●	●	○	○
Croatia	Until the 2005–06 academic year, teachers had to obtain a 4-year university degree. After implementation of the Bologna process, teachers must obtain a Master's degree in Primary Education in the Department of Teacher Education.	●	●	●	●
Czech Republic	All teachers receive their education through a university degree program. Teachers of Grades 1–5 receive a master's degree after a 5-year course at a university department of education.	●	●	○	○
Denmark	All teachers receive their education at a university school for teacher education with a 4-year professional bachelor program.	●	●	○	○
England	Teachers receive either a degree in education or a degree in a subject plus a post-graduate certificate in education.	●	●	●	○
Finland	All teachers must receive a university master's degree. Grade 4 teachers have majored in education.	●	○	○	○
Georgia	Most teachers receive their education through a university degree program.	○	●	○	●
Germany	Teacher education is offered at universities, colleges of education, and colleges of art and music. Programs for primary school teachers typically last 4–5 years.	●	●	●	●
Ghana	Most teachers receive their education through a university degree program. Some have attended a teacher college program, but that is becoming less common.	○	●	○	●
Honduras	All teachers receive their education through a high school degree program.	●	○	○	○
Hong Kong SAR	Teachers receive their education either through a teacher college program or, more commonly, through a university degree program.	●	●	○	○
Hungary	Teachers receive their education through a university degree program where they are trained in all subjects.	●	●	○	○
Indonesia	Most teachers receive their education through a teacher college program.	●	●	○	○
Iran, Islamic Rep. of	Most teachers receive their education through a university (bachelor's degree) or teacher training center (associate degree) program in primary education.	○	●	○	○
Ireland	Teachers either receive a 3-year bachelor's degree in education or an 18-month post graduate diploma in education after a non-education degree.	●	●	●	○
Israel	Most teachers receive their education through teacher college programs. Some receive their education through a university degree followed by 1 year of study towards teaching licensure.	●	○	●	●
Italy	All teachers must have a university degree in education. Before 1999–2000, a high school diploma with teacher training specialization was sufficient.	○	●	●	●
Japan	Teachers must have an elementary school teaching certificate and pass a teacher appointment examination offered by the local board of education.	●	●	●	●
Jordan	Teachers receive their education through a university degree program.	○	○	○	○
Kazakhstan	Most teachers receive their education through a pedagogical higher education institution or pedagogical college.	●	●	●	●

● Yes ○ No

A dash (–) indicates data not provided.

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 25: Main Preparation Route and Current Requirements for Fourth Grade Teachers (Continued)

Country	Main Teacher Preparation Route	Current Requirements: Supervised Practicum During Teacher Education Program	Current Requirements: Passing a Qualifying Examination (e.g., licensing, certification)	Current Requirements: Completion of Probationary Teaching Period	Current Requirements: Completion of Mentoring or Induction Program
Korea, Rep. of	Most teachers receive their education through a national university of education; some receive their education in a teacher college through the department of elementary education in a teachers' college.	●	●	○	●
Kuwait	Teachers in primary education must have a university degree from the Department of Education at the University of Kuwait, the College of Basic Education, or any equivalent university degree from the other countries.	●	○	●	●
Lebanon	–	–	–	–	–
Lithuania	Primary school teachers are trained either at 4-year pedagogical universities (baccalaureate) or 3-year teacher training colleges.	●	○	○	○
Macedonia, Rep. of	Teachers are required to attend university departments of pedagogy.	●	●	●	●
Malaysia	Most teachers have attended a diploma course in teacher training colleges; recently, many teachers may have graduated from a university.	●	●	●	●
Malta	Most primary teachers have a Bachelor of Education in Primary teaching from a 4-year university degree program.	●	●	●	●
Morocco	Most teachers have a general university diploma and then complete a teacher training course.	●	●	●	●
Netherlands	Most teachers receive their education from a 4-year teacher training college program.	●	●	●	○
New Zealand	Most teachers complete either a 3-year Bachelor of Education program, a 4-year conjoint degree program, or a 1-year compressed graduate diploma after a non-education degree.	●	○	●	○
Northern Ireland	Teachers have either a 4-year Bachelor of Education degree or a 1-year Postgraduate Certificate in Education.	●	●	○	●
Norway	Most teachers attend a 4-year teacher education college program.	●	●	○	○
Oman	All teachers receive their education through a university degree program.	●	○	○	●
Palestinian Nat'l Auth.	Most teachers receive their education through a university degree program.	○	●	●	○
Poland	Most teachers receive their education through a university degree program; some have attended a teacher college, but most then complete a 2-year master's degree university course.	●	○	●	○
Portugal	Most teachers receive their education through a university or a polytechnic degree program (high education diploma).	●	○	●	○
Qatar	Teachers must have a degree in primary education from a university or teacher college, with many now having specialized majors in the subject they teach.	○	○	○	○
Romania	Most teachers receive their education through a university degree program.	●	●	●	●
Russian Federation	Most teachers receive their education through a pedagogical institute or university degree program. Some have attended a teacher college program, but this is becoming less common.	●	●	○	●
Saudi Arabia	Most teachers have attended a teacher college program, though some teachers receive their education through a university degree program.	●	●	○	○
Serbia	Most primary school teachers have a university degree.	●	●	●	●
Singapore	All prospective primary school teachers are required to undergo pre-service teacher education conducted by the National Institute of Education, Nanyang Technological University. They can obtain either a 2-year Diploma in Education, a 4-year Bachelor of Arts/Science (Education), or a 1- or 2-year Postgraduate Diploma in Education.	●	●	●	●
Slovak Republic	Teachers are mostly educated at Departments of Pedagogy, and are required to have a master's degree.	●	●	○	●
Slovenia	Most teachers receive their education through a university degree program.	●	●	●	●
South Africa	Most teachers complete either a 4-year university degree in education or a 3-year non-education degree followed by a 1-year postgraduate certification in education. Before 1996, teachers could attend a teacher college instead of university.	●	●	○	○
Spain	Primary teachers need to complete a 3-year university degree program. Since 2010, future teachers entering university need to complete a 4-year degree.	●	●	●	○

● Yes ○ No

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 25: Main Preparation Route and Current Requirements for Fourth Grade Teachers (Continued)

Country	Main Teacher Preparation Route	Current Requirements			
		Supervised Practicum During Teacher Education Program	Passing a Qualifying Examination (e.g., licensing, certification)	Completion of Probationary Teaching Period	Completion of Mentoring or Induction Program
Sweden	Most teachers receive their education through a university degree program.	●	●	○	○
Syrian Arab Republic	Most teachers receive their education through a university degree program.	●	●	○	○
Thailand	Teachers must complete at least a bachelor's degree with 1 year of teaching coursework.	●	○	○	○
Tunisia	Most teachers qualifying for university entrance must then successfully pass an exam to attend a training period before starting to teach.	●	●	●	○
Turkey	Teachers receive their education through a 4-year university degree program.	●	○	●	●
Ukraine	Most teachers have a degree from a pedagogical college or a university.	●	●	○	●
United Arab Emirates	Most teachers receive their education through a university degree program.	○	●	●	○
United States	Requirements set by states. Most teachers receive their education through a university degree program in education; candidates with degrees in other areas may become certified to teach through an alternative teacher certification program. Typically, state licensing boards grant credentials to teachers, with recertification after a set period of time.	●	●	●	●
Yemen	Teachers must have a university degree.	●	○	●	○
Benchmarking Participants—Responses Pertain to Benchmarking Provinces/Emirates/States					
Alberta, Canada	Most teachers receive their education through a university degree program.	●	○	●	○
Ontario, Canada	Most teachers obtain a university degree, followed by a 1-year Bachelor of Education program.	●	○	○	●
Quebec, Canada	Most teachers receive their education through a university degree program.	●	●	○	○
Abu Dhabi, UAE	All public school teachers have a university degree. Recently hired teachers are required to have an education degree or teaching certificate. There is enormous range in private schools, from teachers with high school diplomas to licensed teachers with graduate degrees.	●	○	○	○
Dubai, UAE	Most teachers have a qualified background in teaching and a teaching certificate.	Varies by school type	Varies by school type	Varies by school type	Varies by school type
Alabama, US	Teachers receive their education through a university degree program and specialize in a specific grade level. Teachers also must pass an exam to receive an Alabama Teaching Certificate.	●	●	●	●
California, US	Teachers must have earned a Multiple Subject Teaching Credential, which requires a baccalaureate or higher university degree as well as completion of a multiple subject student teacher preparation program.	●	●	●	●
Colorado, US	Teachers must complete an approved program at an Institution of Higher Education.	●	●	○	●
Connecticut, US	Teachers must have earned at least a university bachelor's degree. Generally, new teachers must complete a master's degree within 11 years of starting teaching.	●	●	●	●
Florida, US	Most teachers complete an Initial Teacher Preparation program. Individuals who complete this program earn a bachelor's or master's degree in education specific to the subject area in which they are being prepared.	●	●	●	●
Indiana, US	Most fourth grade teachers complete a bachelor's degree in elementary education at an accredited institution of higher education.	●	●	●	●
Massachusetts, US	Teachers must have a bachelor's degree, complete an educator preparation program, and pass the Massachusetts Test for Educator Licensure.	●	●	●	●
Minnesota, US	Teachers must have a bachelor's degree, pass state required exams, and complete a teacher preparation program.	●	●	○	○
North Carolina, US	Teachers receive their education through a university degree program.	Varies by college or university	●	●	●

● Yes ○ No

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 26: Main Preparation Route and Current Requirements for Eighth Grade Teachers

TIMSS 2011 Mathematics & Science 8th Grade

Reported by National Research Coordinators

Country	Main Teacher Preparation Route	Current Requirements: Supervised Practicum During Teacher Education Program	Current Requirements: Passing a Qualifying Examination (e.g., licensing, certification)	Current Requirements: Completion of Probationary Teaching Period	Current Requirements: Completion of Mentoring or Induction Program
Armenia	Most teachers receive their education through a university degree program.	●	●	●	●
Australia	Most teachers receive a 4-year university degree in education, or complete a 1–2 year postgraduate qualification program following a 4-year non-education degree.	●	○	●	○
Austria	Teachers in lower level general secondary school receive a bachelors' degree from a 6-semester education at University Colleges of Teacher Education; teachers in lower level academic secondary school receive a master's degree from a 9-semester education at the university followed by a 1-year probationary teaching period.	●	●	●	○
Azerbaijan	Most teachers receive their education through a university degree program.	●	●	○	●
Bahrain	Most teachers have a Bachelor's of Education from the College of Education or a post-graduate diploma in education following a non-education degree.	○	○	○	●
Belgium (Flemish)	Teacher training for Grades 7 and 8 of secondary education consists of a 3-year college program. Teachers must specialize in some subject areas.	●	●	○	○
Botswana	Teachers obtain a Diploma in Secondary Education from colleges of education.	●	●	●	○
Chile	Most teachers receive their education through a university degree program, although some attend professional institute programs (no bachelor's degree).	●	○	○	○
Chinese Taipei	Most teachers receive their education through a university degree program.	●	●	○	○
Croatia	Until the 2005–06 academic year, teachers had to obtain a 4-year university degree. After implementation of the Bologna process, teachers who teach biology, chemistry, physics, and geography must obtain a master's degree in their subject area, together with the required pedagogical, psychological, and methodological skills.	●	●	●	●
Czech Republic	All teachers receive their education through a university degree program. Teachers receive a master's degree after a 5-year course at a university department of education. Upper secondary teachers are specialized only in 2 subjects.	●	●	○	○
Denmark	All teachers receive their education at a special university college for teacher education with a 4-year professional bachelor program.	●	●	○	○
England	Teachers receive either a degree in education or, more often, a degree in a subject plus a post-graduate certificate in education.	●	●	●	○
Finland	All teachers must receive a university master's degree. Eighth-grade teachers are subject teachers who major in the main subject they teach.	●	○	○	○
Georgia	Most teachers receive their education through a university degree program.	○	●	○	●
Germany	Teachers must hold a university degree. The program of study for secondary school teachers is slightly longer than for primary school teachers and emphasizes professional content knowledge.	●	●	●	●
Ghana	Most teachers receive their education through a university degree program. Some have attended a teacher college program, but that is becoming less common.	○	●	○	●
Honduras	Eighth-grade teachers are supposed to hold a university degree in the subject area that they teach, though this rule is not usually enforced.	●	○	○	○
Hong Kong SAR	Eighth-grade teachers receive their education either through a teacher college program or, more commonly, through a university degree program.	●	●	○	○
Hungary	Teachers receive their education through a master's degree program. Teachers in Grades 5–8 are trained in their specific subjects.	●	●	○	○
Indonesia	Most teachers receive their education through a teacher college program.	●	●	○	○
Iran, Islamic Rep. of	Most teachers receive their education through a university (bachelor's degree). For mathematics and science teachers, mathematics or science education programs are required in addition to an education degree.	○	●	○	○
Ireland	Teachers receive a 3-year degree (including at least one subject in the post-primary school curriculum) followed by a 1-year post-graduate qualification in education. Alternatively, a teacher could pursue a concurrent non-education degree and teacher training.	●	●	●	○
Israel	Most teachers receive their education through teacher college programs. Some receive their education through a university degree followed by 1 year of study towards teaching licensure.	●	○	●	●
Italy	Teachers must have a university degree in the subject which they teach.	○	●	●	●

● Yes ○ No

A dash (–) indicates data not provided.

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 26: Main Preparation Route and Current Requirements for Eighth Grade Teachers (Continued)

Country	Main Teacher Preparation Route	Current Requirements: Supervised Practicum During Teacher Education Program	Current Requirements: Passing a Qualifying Examination (e.g., licensing, certification)	Current Requirements: Completion of Probationary Teaching Period	Current Requirements: Completion of Mentoring or Induction Program
Japan	Teachers must have a lower secondary school teaching certificate and pass a teacher appointment examination offered by the local board of education.	●	●	●	●
Jordan	Teachers receive their education through a university degree program.	○	○	○	○
Kazakhstan	Most teachers receive their education through a pedagogical higher education institution.	●	●	●	●
Korea, Rep. of	Most 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.	●	●	○	●
Kuwait	Teachers in secondary education must have a university degree from the Department of Education at the University of Kuwait, the College of Basic Education, or any equivalent university degree from the other countries.	●	○	●	●
Lebanon	–	○	○	○	○
Lithuania	Teachers are trained either at pedagogical universities (bachelor's or master's degree) or general universities by completing professional teachers' studies in addition to their bachelor studies.	●	○	○	○
Macedonia, Rep. of	Teachers are required to attend university departments of pedagogy.	●	●	●	●
Malaysia	Most teachers have attended a diploma course in teacher training colleges; recently, many teachers may have graduated from a university.	●	●	●	●
Malta	Most teachers of eighth grade students have a 4-year Bachelor of Education degree in Secondary teaching. However, a small number of teachers follow a 3-year Bachelor of Arts or Bachelor of Science degree with a 1-year Postgraduate Certificate in Education.	●	●	●	●
Morocco	Most teachers have a general university diploma and then complete a teacher training course.	●	●	●	●
Netherlands	Secondary teachers must have a diploma from a secondary school teacher training college or a university diploma. In most cases, teachers have a university degree in a subject and an additional degree in general education.	●	●	●	○
New Zealand	Teachers either obtain a university degree in a subject and then a 1-year graduate diploma, or participate in a conjoint degree program (e.g. Bachelor of Science/Bachelor of Teaching).	●	○	●	○
Northern Ireland	Teachers have either a 4-year Bachelor of Education or a 1-year Postgraduate Certificate in Education.	●	●	○	●
Norway	Teachers either attend a 4-year teacher education college program, or obtain a university degree with specialization in two subjects.	●	●	○	○
Oman	All teachers receive their education through a university degree program, including subject-specific and pedagogical coursework .	●	○	○	●
Palestinian Nat'l Auth.	Some teachers receive their education through a university degree program.	○	●	●	○
Poland	Most teachers receive their education through a university degree program; some have attended a teacher college, but most then complete a 2-year master's degree university course.	●	○	●	○
Portugal	All teachers for eighth grade receive their education through a university degree program.	●	○	●	○
Qatar	Teachers must have a Bachelor's of Education and a major in the subject taught.	○	○	○	○
Romania	Secondary teachers have a university degree in the subject area they teach, as well as general teacher preparatory coursework.	●	●	●	●
Russian Federation	Most teachers receive their education through state universities or pedagogical universities or institutes.	●	●	○	●
Saudi Arabia	Most teachers have attended a teacher college program, though some teachers receive their education through a university degree program.	●	●	○	○
Serbia	Subject teachers (teachers for Grades 5–8) are trained in their respective academic discipline, and participate in some level of teacher preparatory coursework.	●	●	●	●
Singapore	All prospective secondary school teachers are required to undergo pre-service teacher education conducted by the National Institute of Education, Nanyang Technological University. They can obtain either a 4-year Bachelor of Arts/Science (Education), or a 1- or 2-year Postgraduate Diploma in Education.	●	●	●	●

● Yes ○ No

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Exhibit 26: Main Preparation Route and Current Requirements for Eighth Grade Teachers (Continued)

Country	Main Teacher Preparation Route	Current Requirements: Supervised Practicum During Teacher Education Program	Current Requirements: Passing a Qualifying Examination (e.g., licensing, certification)	Current Requirements: Completion of Probationary Teaching Period	Current Requirements: Completion of Mentoring or Induction Program
Slovak Republic	Teachers hold a university master's degree and usually specialize in 2 subjects. They are educated either at Departments of Pedagogy or other departments within the subject area.	●	●	○	●
Slovenia	Teachers hold a university degree and usually specialize in 2 subjects.	●	●	●	●
South Africa	Teachers receive their education through a university degree program. Before 2001, teachers attended a teacher college. Eighth-grade teachers specialize in the subject(s) they teach.	●	○	○	○
Spain	Eighth grade teachers acquire a university degree in a specific subject, followed by a Master of Teaching in Secondary Education.	●	●	●	○
Sweden	Most teachers receive their education through a university degree program.	●	●	○	○
Syrian Arab Republic	Most teachers receive their education through a university degree program. Some have attended a teacher college program, but that is becoming less common.	●	●	○	○
Thailand	Teachers must complete at least a bachelor's degree with 1 year of teaching coursework.	●	○	○	○
Tunisia	Teachers must have a university degree and pass an additional examination.	●	●	●	○
Turkey	Teachers receive their education through a 4-year university degree program.	●	○	●	●
Ukraine	Teachers must have a university degree.	●	●	○	●
United Arab Emirates	Most teachers receive their education through a university degree program.	○	●	●	○
United States	Requirements set by states. Most teachers receive their education through a university degree program in education; candidates with degree in other areas may become certified to teach through an alternative teacher certification program. Typically, state licensing boards grant credentials to teachers, with recertification after a set period of time.	●	●	●	●
Yemen	Teachers must have a university degree.	●	○	●	○
Benchmarking Participants—Responses Pertain to Benchmarking Provinces/Emirates/States					
Alberta, Canada	Most teachers receive their education through a university degree program.	●	○	●	○
Ontario, Canada	Teachers must have a Bachelor of Education (Intermediate certification). Most teachers obtain a university degree, followed by a 1-year Bachelor of Education program.	●	○	○	●
Quebec, Canada	Eighth-grade teachers receive a degree in secondary education through a university degree program, usually specializing in 1–2 subjects.	●	●	○	○
Abu Dhabi, UAE	Public school teachers have university degrees in the subjects they teach. Recently hired teachers also have a teaching credential, though many long-term teachers do not. There is enormous range in private schools, from teachers with high school diplomas to licensed teachers with graduate degrees.	●	○	○	○
Dubai, UAE	Most teachers have a qualified background in teaching and a teaching certificate.	Varies by school type	Varies by school type	Varies by school type	Varies by school type
Alabama, US	Teachers receive their education through a university degree program and specialize in a specific grade level or content area. Teachers also must pass an exam to receive an Alabama Teaching Certificate.	●	●	●	●
California, US	Teachers must have earned a Multiple Subject Teaching Credential, which requires a baccalaureate or higher university degree as well as completion of a multiple subject student teacher preparation program.	●	●	●	●
Colorado, US	Teachers must complete an approved program at an Institution of Higher Education. Eighth-grade teachers generally specialize in the content area which they teach.	●	●	○	●
Connecticut, US	Teachers must have earned at least a university bachelor's degree. Generally, new teachers must complete a master's degree within 11 years of starting teaching.	●	●	●	●
Florida, US	Most teachers complete an Initial Teacher Preparation program. Individuals who complete this program earn a bachelor's or master's degree in education specific to the subject area in which they are being prepared.	●	●	●	●
Indiana, US	Most eighth grade teachers complete a bachelor's degree in secondary teacher education at an accredited institution of higher education.	●	●	●	●
Massachusetts, US	Teachers must have a bachelor's degree, complete an educator preparation program, and pass the Massachusetts Test for Educator Licensure.	●	●	●	●
Minnesota, US	Teachers must have a bachelor's degree, pass state required exams, and complete a teacher preparation program.	●	●	○	○
North Carolina, US	Teachers receive their education through a university degree program.	Varies by college or university	●	●	●

● Yes ○ No

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS 2011

Armenia

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Introduction

Overview of the Education System

Article 35 of the first Constitution of the Republic of Armenia, adopted in 1995, states that every citizen has the right to an education. The Armenian education system includes all levels of education from preschool through post-graduate studies. General education is free of charge, and every citizen has the right on a competitive basis to receive professional education, also free of charge, at national professional education institutions.[1]

The Ministry of Education and Science is responsible for oversight and implementation of education in Armenia and all Armenian schools fall under their purview. The government funds the majority of schools, and the maintenance and development of the education system is considered a national priority.[2] Non-governmental educational institutions also exist in the Republic and are monitored by the Ministry of Education and Science. In addition to monitoring the overall quality of education in Armenian schools, the ministry sets national education standards, defines educational programs at the different levels of education, and issues directives to ensure continuity in the education system, including networks to support educational institutions implementing various educational programs. In addition, the ministry oversees the educational system's management bodies and their subordinate entities and institutions.

On April 14, 1999, the National Assembly of the Republic of Armenia adopted the Law on Education, which established the Education Development State Program—the organizational basis of national education policy.[3] The Law on Education was followed by the development and adoption of laws and legal and normative documents regulating the separate levels of education. The Law on Education has been amended as needed to address various issues that have arisen since its adoption, and it currently guides the development of the system as well as education reform efforts.

In 2003, the ministry began the Education Quality and Relevance reform project. The first stage of this project lasted from 2003 until 2009 and aimed to increase the quality of education and ensure its relevance to the new economy and knowledge society, as well as to improve the efficiency of the education system.[4] Objectives of this phase of the project included developing a national curriculum framework, implementing a national entrance examination for higher education, and providing teachers' opportunities to upgrade their professional qualifications. The second phase of the project began in 2009 and is scheduled for completion in 2014. The purpose of the second phase is for the education system to foster development of a knowledge economy in Armenia by ensuring the quality of both general and tertiary education. This ongoing reform includes improving the effectiveness of information and communication technologies (ICT) in instruction, establishing an institutional system of professional development for teachers, and reformulating teacher education.

The National Assembly approved the *National Curriculum for General Education* framework in May 2004, followed by approval of the *State Standards for Secondary Education* in June of the same year.[5] In the 2006–07 academic year, the education system began the transition from a ten-year program to a twelve-year, three-level system for general education. This major reform was fully implemented in 2009. Under the new structure, education in Armenia includes the following:

- Preschool education to support families, comprising day nursery schools (*creche*) for children ages 2–3, kindergartens for children ages 3–6, and joint day nursery-kindergarten schools;
- General education, comprising primary schools (Grades 1–4), middle schools (Grades 5–9), and high schools (Grades 10–12);
- Vocational education, comprising preliminary and middle level vocational schools and higher education; and
- Higher education, comprising bachelor's and master's degree programs, specialist training programs, and qualification improvement programs provided at both state and private education institutions, as well as a certified specialist education system.

As a result of the reforms and the expansion from ten grades to twelve, general education has undergone significant changes. The reform process necessitated the review and revision of education programs, textbooks, and standards. This process will conclude by the end of 2012. For the first time, the subject standards will define knowledge, skills, and values to be achieved in each subject.[6] Student understanding of these areas will be assessed and rated on a three-level scale: minimal, average, and excellent.

The curriculum content coverage for each school year has been reorganized so that topics are covered in more depth and the number of critical thinking and application exercises included in each subject has increased, especially in Grades 1–9. New course materials have been introduced to support the new curricular focus and more attention has been directed to hands-on and laboratory exercises. Classroom instruction has become increasingly discussion-based and aimed at engaging students' critical thinking and logical reasoning skills.

A network of high schools has been created to improve the quality of education. By the end of 2012, 140 schools will have joined the network. Education in the network schools is implemented using field concentrations (e.g., physics and mathematics, science, foreign languages, and social studies), and students may choose concentrations according to their interests.

Languages of Instruction

Armenian is the official language of Armenia and the official language of instruction.[7] The population in Armenia is approximately 3.2 million, comprising Armenians (97.9%), Yezidis (1.3%), Russians (0.5%), and others (0.03%).[8] Yezidis are non-Muslim Kurds who mostly live in central Armenia and constitute Armenia's largest ethnic minority.

Mathematics Curriculum in Primary and Lower Secondary Grades

The mathematics curriculum in Grades 1–4 includes the following main topics:

- Arithmetic operations (addition, subtraction, multiplication, and division) on natural numbers;
- Speed, time, and distance;
- Algebraic expressions and computations;
- Fractions; and
- Geometric shapes.

The mathematics curriculum in Grades 5 and 6 includes:

- Natural numbers and scales;
- Operations with fractions (addition, subtraction, multiplication, division, finding common denominators, and reduction to lowest terms);
- Angles (properties and measurement);
- Percents; and
- Rational numbers and expressions.

In Grades 7–9, mathematics is divided into Algebra and Geometry, and the main topics covered in each domain are as follows:

- Algebra—Arithmetic operations (addition subtraction, multiplication, and division), monomials with positive integer exponents, simple algebraic proofs, equations in a single variable, binomials, square roots, quadratic polynomials, systems of linear equations, fractional exponents, arithmetic 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.

Science Curriculum in Primary and Lower Secondary Grades

Science in the primary and lower secondary grades is divided into two subjects: Nature (Grades 1–4), and Natural Science (Grades 5 and 6). 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 used in everyday life; and
- Understand the necessity of preserving the environment and one's health.

The following is the basis for structuring the science content:

- Research work and activities;
- Nature's systems;
- Nature's processes; and
- Humans and the environment.

Science in Grades 7–9 includes Geography, Geography of Armenia, Physics, Chemistry, and Biology. The curriculum of these subjects includes the following topics:

- Physics—The concept of a "body" in physics and simple measurements; a body's movement and interactions in a reference frame; work, power, and simple machines; structure of materials; pressure; kinematics; dynamics; mechanical vibrations and waves; heat and temperature; electrical 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 bonds and the structure of a molecule; electrolytic dissociation; subgroups of elements in Groups 14–17 of the periodic table; and organic compounds.
- Geography—The Earth and its atmosphere (as an envelope of gases); continents and oceans; geography of Armenia (relief, climate, natural resources, rivers, and lakes); nations of the world (natural resources, populations, and economies); the Republic of Armenia (population and economy); and the Republic of Nagorny Kharabakh (natural resources, population, and economy).
- Biology—Lower plants (algae); higher plants (moss, ferns, gymnosperms, and angiosperms); bacteria and fungi; protozoa (infuzoria and sporozoans), metazoa (types of coelenterates, worms, molluscoids, and arthropods); chordates (fish, amphibian, reptile, birds, mammals); humans (blood, blood circulation and the immune system); the respiratory, digestive, excretory, nervous, musculoskeletal, and endocrine systems; the reproductive system; sense organs and skin; and metabolism.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Mathematics instruction is provided five periods per week for students in Grades 1–6. For students in Grades 7–9, Algebra is offered three periods per week and Geometry is offered two periods per week. Science instruction is provided one period per week for students in Grades 1–4 as part of the subject Nature. Beginning in fifth grade, science is taught as separate subjects. In Grades 5 and 6, science instruction comprises Natural Science for two periods per week as well as Nature (one period per week for Grade 5) or Geography (one period per week for Grade 6). In Grades 7–9, students receive instruction in Geography, Geography of Armenia, Physics, Chemistry, and Biology for between one and two periods per week per subject depending on the grade level.

Instructional Materials, Equipment, and Laboratories

All schools in Armenia use the same textbooks, which are chosen by special institutions within the Ministry of Education and Science on a competitive basis. However, teachers may incorporate alternative textbooks. As part of the education reforms, new textbooks were developed based on a review of an array of texts from several different countries.

Schools, especially high schools, are equipped with science equipment and laboratories. Teachers also use models (e.g., molecules, physical systems, body parts of people, animals and plants, and the Earth), posters (e.g., pictures of famous scientists with accompanying biographies, and scientific formulae), maps, globes, and other support materials in their lessons.

Use of Technology

All schools are equipped with computers and almost all schools have Internet access. However, some small schools in outlying provinces are under-resourced. Many schools have a computer center where classes can meet, increasingly enabling teachers to integrate ICT into their lessons. Also, training sessions in ICT skills are held continuously to help teachers improve their computer literacy.

In addition to ICT infrastructure within schools, networks have been established between schools. At the ministry level, a special institute has been established to coordinate ICT programs in schools, provide professional development in ICT skills for teachers, manage the inter-school networks, and develop and disseminate electronic learning materials and education programs.

An education portal also has been established to aid the dissemination of information within the education community. Lastly, the National Center of Educational Technology has been established to develop and implement ICT programs in secondary schools.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

In general, Armenian students do not have subject-specific teachers for mathematics and science in the primary grades (Grades 1–4). Beginning in middle school, students have separate teachers for mathematics and each science subject.

Homework Policies

There is no national policy on homework. However, teachers commonly assign different types of exercises, such as review, practice, and application problems, practice sets of sample test items, lesson summaries, and experiments for students to complete at home.

As a part of the re-designed frameworks and curriculum, homework practices have evolved concurrently with classroom practices. Under previous frameworks, many lessons involved the teacher explaining the new lesson to students, solving some practice exercises for modeling purposes, and assigning homework involving learning the theoretical portion of the lesson and completing a written assignment. Then, during the next lesson, the teacher would orally check for understanding of the theoretical portion of the lesson and score the written exercises. In addition, all exercises previously were conducted using paper and pencil. The new reforms promote the use of other types of exercises and review. In addition, the frameworks and curriculum reforms have been complemented by concurrent reforms in student assessment. These latter reforms permit teachers to use test items as part of the instructional process as well as group work, which may also be used as a part of formal classroom assessment.

Teachers and Teacher Education

Teacher Education Specific to Mathematics and Science

The State Pedagogical University of Armenia graduates most of Armenia's teachers. Other universities, such as Yerevan State University and the Linguistic University after V. Brusov, as well as professional pedagogical colleges prepare teachers. Teachers must have a university or college diploma to teach and generally hold bachelor's and master's degrees both in education and in a second content area.

Requirements for Ongoing Professional Development

Recent reforms have focused on upgrading current teacher qualifications. The philosophy guiding the reforms is that a good education is necessary to become a professional teacher and the key factor in a successful education system is teachers' professional development. Teachers are the core players in general education reform and their continuous professional development is therefore vital.

Since 2005, extensive professional development courses have involved teachers in educational reform by positioning them as leaders in the process. The courses lead to various examinations, and passing these courses results in a license that qualifies teachers to pursue further professional development. To ensure effective use of new curricula, syllabi, standards, and assessment tools, teachers receive subject-based professional development, which follows the sequence of a given subject's syllabus. Professional development is conducted using the train-the-trainer model (i.e., international experts instruct a core group of central trainers who, in turn, instruct local trainers, and this latter group trains teachers). School-based professional development sessions are conducted by 52 school-centers that are selected from all eleven *marzes*, or provinces of Armenia, and by the National Institute of Education and its eleven *marz* branches. Approximately 4,100 teachers have participated in development courses in different subjects. Approximately 200–300 trainers have been prepared to instruct each subject in the professional development courses, and there is significant potential to further expand the process.

With current increases in the flow of information, the main goal of education now is teaching students how to learn. Thus, education in Armenia has shifted from emphasizing mastery and the simple reproduction of knowledge to enabling students to select knowledge, develop practical skills, and competencies, and understand how to apply them. This new focus assumes effective cooperation between students and their teachers and develops students' capability to organize their learning independently. In the educational process, this goal may be achieved using both interactive and cooperative learning methods. To help teachers develop these pedagogical skills, three-day seminars on application of cooperative learning methods are offered to teachers.

Professional development also is now required for current principals and is part of a new licensing process.

Monitoring Student Progress in Mathematics and Science

Student progress in mathematics and science is monitored both by classroom teachers and through nation-wide standardized tests. The Assessment and Testing Center organizes external assessments twice a year for students in sixth grade and higher. The testing is performed not only for national monitoring purposes, but also to assist teachers in organizing classroom assessments by developing their skills in test development, test administration, scoring, and analysis of their own tests. Official final examinations are administered at the end of fourth grade (the end of primary school) and at the end of ninth grade (the end of middle school). The fourth-grade examination is diagnostic, while the ninth grade examination is used to determine graduation from middle school.

Students wishing to attend university used to take subject-specific entrance examinations over the course of several days. Each university organized its own examinations according to its own requirements and tasks, and results were not generalizable across the various institutions. Under the new reforms, university entrance examinations have been centralized into a system organized by the Testing and Assessment Center, which uses fair, reliable, impartial, valid, and accessible standardized tests. At the end of twelfth grade, all students take this new unified examination, which determines both high school graduation and university entrance.

Students also participate in national assessment surveys. The HAAS tests (on Armenian language and literature and on Armenian History) were administered in 2010. A national assessment of science subjects (physics and chemistry), BAAS, was administered in 2011 and a national assessment of other subjects (biology and geography) is planned for 2012.

Impact and Use of TIMSS

Armenia has participated in TIMSS since 2003. Prior to 2003, standardized testing was not commonly used as a form of assessment in Armenia. As a result of Armenia's participation in TIMSS, a new culture of testing has emerged. This culture has begun to influence the review of curricula, textbooks, and assessment methods, all of which previously had a greater theoretical emphasis and incorporated fewer practical exercises.

Participation in TIMSS has significantly informed the development of national assessments, final examinations, and university admissions examinations. For example, when Armenia participated in TIMSS 2007, previous experience with the testing process led to closer examination of the results and the decision to conduct national surveys of different subjects in Armenia. Lastly, because of the recent pedagogical reforms that TIMSS data has informed, assessment now is widely used in all subjects and in different ways (national assessments, final and unified examinations, and national and classroom assessments).

Suggested Readings

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Australia

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Introduction

Overview of the Education System

Australia does not have a single national education system; states and territories are each responsible for their own education administrations, although overall structures are similar. Policy collaboration takes place in joint governmental councils that include the federal, state, and territorial governments.

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, regional offices and schools have responsibility for administration, staffing, and curriculum, although the extent of responsibility varies across jurisdictions. Central authorities specify the curriculum and standards framework, but schools have autonomy in deciding curriculum details, textbooks, and teaching methodology, particularly at the primary and lower secondary levels. State authorities specify curriculum for Grades 11 and 12 while also being responsible for examining and certifying student achievement for both government and non-government schools.

In recent years, the degree of involvement of the Australian government and the degree of collaboration between state and territorial governments has increased. In 2008, the federal government and state education ministers agreed to a framework of reform in education—the National Education Agreement.[1] Concurrently, the ministers of education also agreed to the Melbourne Declaration on the Educational Goals for Young Australians, which outlines future directions and aspirations for Australian schooling and supports the National Education Agreement.[2]

Australia's national reform agenda for education includes a number of major national initiatives, including the development of a national curriculum, national standards for teachers and school leaders, and the introduction of a national literacy and numeracy assessment for all students in Grades 3, 5, 7, and 9. Two national agencies—the Australian Curriculum, Assessment, and Reporting Authority and the Australian Institute of Teaching and School Leadership—have been established to support these initiatives.[3]

Children in Australia generally attend preschool or kindergarten part time for one or two years before starting school. Preschools are usually run by local councils, community groups, or private organizations, with some states also offering state-run preschools. Preschool is offered to children ages three to five years old, though attendance varies widely. Recent national policy developments aim to ensure at least 15 hours of preschool per week for all four year olds by 2013.[4] Preschool education is primarily play-based learning and, since 2009, has been supported by the Early Years Learning Framework.[5]

As of 2010, 3,510,875 students attended Australian schools. One-third (34%) attended non-government schools.[6] Minimum school starting ages vary by state and territory, from four years and five months to five years old, but the compulsory starting age is six years old in most states. All states now provide one year of school before Grade 1, variously called Kindergarten, Preparatory (Prep), Transition, Pre-primary, or Reception (referred to as "Foundation" in the Australian curriculum).

The Australian school system is organized around "Years," or Grades; Year 1 (Grade 1) is the first year of formal schooling and Year 12 (Grade 12) is the final year of secondary education. Some states include Grade 7 in primary schools so the number of years of secondary education may cover either Grades 7–12 or Grades 8–12. Following a decision of the Council of Australian Governments in July 2009, there is national agreement on a mandatory requirement for young people to complete Grade 10 and then participate full-time in education, training, or employment until age 17.[7]

Primary school and the first two years of secondary school typically provide a general program that all students follow. In subsequent years of schooling, a basic core of subjects is supplemented with optional subjects for students. In the final two years of secondary school, students have the opportunity to specialize in a range of elective studies, 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.

Australia has no common national policy on ability streaming, grouping, or tracking of students. Streaming is a school-based decision and is not officially promoted in any state. Some schools choose to stream students according to ability, and some offer special enrichment or remedial programs for select groups of students.

As part of the national education reform agenda, the federal, state, and territorial governments entered into a number of Smarter Schools National Partnerships. One such partnership, the Smarter Schools National Partnership for Literacy and Numeracy, recognizes numeracy as a foundation skill. The partnership involves funding over four years from all governments to facilitate and reward the implementation of evidence-based strategies that improve student numeracy skills. It focuses on quality teaching of literacy and numeracy, stronger school leadership, and the effective use of student performance information to identify where students need support.[8]

At the state and territory level, a number of programs support mathematics and science education. One example is the Energizing Science and Mathematics Education Strategy in Victoria, which supports investment in infrastructure, strategic partnerships, workforce capacity, and curriculum resources. The program's aim is to raise the level of science and mathematics achievement of Victorian students, increase student interest and participation and encourage more students to pursue science and mathematics-related careers, and expand the knowledge base of teachers and increase teacher capacity to engage students.[9] Another example is South Australia's Primary Mathematics and Science Strategy. This program aims to achieve sustainable, system-wide improvement in student learning of mathematics and science in primary schools through minimum weekly instruction times, specialist training for teachers and investment in programs and teaching methods that have been proven to be effective. The strategy also includes support for teachers in implementing the new Australian Curriculum in mathematics and science.[10]

Languages of Instruction

English is the language of instruction in education.

The Australian population is mainly of European descent, although recent immigration has produced greater ethnic and cultural diversity. According to the 2006 Census, Australia had a population of about 20 million people. Close to 22 percent of this population was born overseas, and 21 percent spoke a language other than English at home. In addition, almost 400 different languages were spoken in homes across Australia.[11] In the same census, 2.3 percent of the population (over 455,000 people) identified themselves as having an indigenous (Aboriginal or Torres Strait Island) origin.[12] About 5 percent of

Australian school age children are of indigenous background, and some live in isolated communities.[13]

The Australian Curriculum in Primary and Secondary Schools

In 2003, the Ministerial Council on Education, Employment, Training, and Youth Affairs requested the development of statements of learning for English, mathematics, science, and civics and citizenship, as a means of achieving greater national consistency in curriculum outcomes across the eight states and territories. These statements describe essential skills, knowledge, understanding, 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 were primarily intended for use by state and territory departments or curriculum authorities to guide future development. Until the full implementation of the new Australian Curriculum is realized, these statements of learning constitute the best summary of the curricula in use across Australia.

Mathematics Curriculum in Primary and Lower Secondary Grades

The national *Statements of Learning for Mathematics* describe what young Australians should have the opportunity to learn and develop in school up to Grade 9.[14] The statements draw upon goals synthesized from mathematics curricula in place across Australia and 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; logical and algebraic reasoning, and generalization regarding function and pattern; identification and measurement of attributes or characteristics of shapes, objects, data, and chance events; and geometric reasoning and 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 on and discussing mathematical ideas, problems, and processes; formulating and testing solutions, and having these solutions tested by others; and 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 ways that reflect conceptual understanding for various audiences and purposes; and selecting and effectively using a range of mathematical strategies, models, information and communication technologies, and related critical literacies.

- Enjoyment and confidence in using mathematics in everyday situations—Appreciating the relevance of mathematics to personal and working life; appreciating nature as a dynamic, diverse, and complex domain with interwoven and interconnected concepts; and appreciating mathematical thinking and its historical and cultural roles.

The national statements of learning are arranged by grade level and structured around five essential and common mathematical strands:

- Working Mathematically—Involves mathematical inquiry and its practical and theoretical application. Key aspects of working mathematically, individually and with others, include formulation, solution, interpretation, and communication.

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

- Algebra, Function, and Pattern—Involves the study of general relationships between objects and their representation by the formal or informal use of variables.

- Measurement, Chance, and Data—Involves the study of unit, measurement and error, events and likelihood, and data and inference.

- Space—Involves the study of shape and location.

The *Australian Curriculum in Mathematics for Foundation—Year 10* (Grade 10) was published in 2011 and is expected to be implemented in schools between 2011 and 2013.[15]

Science Curriculum in Primary and Lower Secondary Grades

The national *Statements of Learning for Science* describe what young Australians should have the opportunity to learn and develop in school up to Grade 9.[16] The statements draw upon the following goals synthesized from science curricula in place across Australia and 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, as well as 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;
- Appreciate the importance of critical thinking, objectivity, logical reasoning, and ethical practices in science research;
- Experience the excitement and creativity of the scientific enterprise, recognizing that scientific questioning and curiosity seeks to make sense of phenomena;
- Use appropriate ways of representing and communicating science understanding 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 history and way of contributing to society;
- Learn about current Australian research, achievements, and contributions to the community, recognizing that science offers rewarding career pathways and opportunities for lifelong learning;
- Acknowledge that aspects of scientific thinking are conducted by people in different cultural, environmental, and economic contexts, and that cultural contexts influence the development and use of scientific knowledge; and

- Develop an understanding of science concepts and use these to explain and predict events of the physical and biological worlds.

The statements are organized by grade level and are structured around three essential and common aspects of the science curriculum:

- Science as a Human Endeavor—Reflects on the way science influences society through its way of thinking and world view, as well as the way societal challenges or social priorities influence the development of scientific research.
- Science as a Way to Know—Looks at scientific investigation and the way scientific explanations are established through posing questions, planning and conducting investigations, collecting and analyzing evidence, and communicating findings.
- Science as a Body of Knowledge—Considers the body of evolving scientific knowledge by describing opportunities to engage with and increasing understanding of scientific concepts, explanations, and theories.

The *Australian Curriculum in Science for Foundation—Year 10* (Grade 10) was published in 2011, with implementation in schools expected between 2011 and 2013.[17]

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Materials, Equipment, and Laboratories

Each school in Australia is responsible for determining which mathematics and science textbooks are used as teacher and student resources. However, schools must ensure that textbooks cover the key areas and opportunities for learning outlined in the national statements of learning.

According to the report *Teaching Science in Australia: Results from the TIMSS 1999 Video Study,* Australian teachers and students were relatively well provided with science laboratories, microscopes, and reference materials. At the time, however, teachers reported a shortage of computers and software.[18]

Use of Technology

The use of calculators in mathematics is widespread in Australian schools. The Australian national report on TIMSS 2007 mathematics indicated that 95 percent of teachers at Grade 4 allowed the use of calculators in the classroom, mainly to check answers, solve complex problems, and explore number concepts.[19] Similarly, 99 percent of Australian teachers at Grade 8 allowed the use of calculators, mostly for routine computations, checking answers, and solving complex problems. TIMSS 2007 also found that 78 percent of fourth grade students had access to a computer in their classrooms; however, computers were used moderately in mathematics to practice skills and procedures. At the eighth grade, with mathematics being taught in general classrooms (rather than in specialized laboratories), only 51 percent of Australian teachers had access to a computer and only 3 percent of classrooms used computers for more than half of mathematics lessons.[20]

In order to support the use of technology in schools, the federal, state, and territorial governments are jointly supporting the Digital Education Revolution. This institute provides funding to support the effective integration of information and communication technology in Australian schools in order to prepare students for life in a digital world.[21]

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Students in Australian primary schools usually have one teacher for most subjects, although some teachers have completed special training in particular subjects. Unlike in primary schools, students in secondary schools generally have a different teacher for separate subject areas and should have access to teachers with specialized education in mathematics or science for these classes.

Teachers and Teacher Education

Teacher Education Specific to Mathematics and Science

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

1. Postgraduate qualification in education, following successful completion of a bachelor's degree—Most secondary school science and mathematics teachers follow this route, enabling subject-specific specialization. Courses usually are one year, although two-year programs also have been developed. Four years of higher education is the average length of initial training for secondary school teachers.

2. Concurrent bachelor's degree program combining liberal arts studies and education—Most undergraduate teacher education programs for students intending to become primary school teachers are either four-

year education degrees or dual degree programs completed concurrently. However, these programs offer limited opportunity to develop specialist knowledge in mathematics or science. Primary school teachers who have completed a three-year teaching diploma may upgrade their qualifications by completing either a specialist one-year diploma or a general fourth year resulting in a bachelor's degree.

Requirements for Ongoing Professional Development

The Australian Institute for Teaching and School Leadership was established in 2010 to provide national leadership for the federal, state, and territorial governments in promoting excellence in the profession of teaching and school leadership. The institute has responsibility for the creation and maintenance of national professional standards for teaching and school leadership as well as the promotion of high quality professional development for teachers and school leaders (including the accreditation of pre-service teacher education).

Australian education authorities recognize that professional development is imperative to maintain the vitality of the profession. A 2007 national survey of school staff indicated that, on average, teachers had spent nine to ten days engaged in professional learning over the previous twelve months, with no significant differences between primary and secondary school teachers or across regions.[22] An earlier study had indicated that these nine to ten days were divided between two to five days of professional development during school hours and more than four days outside of school hours.[23] The 2007 survey also indicted that 58 percent of mathematics teachers in lower secondary school had engaged in professional learning activities in the previous twelve months.[24]

Revised professional standards are being implemented beginning in 2011, and describe expectations for teachers across three domains—Professional Knowledge, Professional Practice, and Professional Engagement—and four career stages—Graduate, Proficient, Highly Accomplished, and Lead.[25] The Graduate and Proficient stages enumerate the mandatory requirements for entry into the profession. For beginning teachers, the requirements permit provisional registration, while teachers with the requisite experience may gain full registration.

Monitoring Student Progress in Mathematics and Science

In 2002, federal and state education authorities established the National Assessment Program for Australia, which has been managed by the Australian

Curriculum, Assessment, and Reporting Authority since 2009. The program involves the following:

- 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 three years; and
- Participation in TIMSS and PISA.

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 in Australia. In addition to participating in the national assessment program, state and territorial authorities conduct assessments in their jurisdictions in areas not encompassed by the national program.[26]

At the end of secondary school in Grade 12, all states conduct formal assessments of student performance in subjects. The purpose of these assessments is to certify student achievement at the end of school, while also providing the basis for selection of courses in higher education. In most states, 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. Queensland and the Australian Capital Territory conduct no external examinations; however, internal school assessments are adjusted against students' scores on an aptitude test to achieve comparability across schools. In New South Wales, all students in Grade 10 are tested in English, mathematics, and science. Other states do not have formal examinations other than at Grade 12.[27]

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, assessment takes the form 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 occasionally make use of assessment tools, including online assessment tools, developed by non-profit organizations (such as the Australian Council for Educational

Research and Educational Services Australia, formerly the Curriculum Corporation) and commercial suppliers. Over the past ten years, use of a wider range of assessment instruments (rather than just traditional written tests) has expanded, as has 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.

Impact and Use of TIMSS

Australia has participated in every cycle of TIMSS since 1995, at both Grades 4 and 8, including the video study. This long and continuous participation has ensured the position of TIMSS as an important source of information for educators and policymakers across Australia.

The Australian Government's National Assessment Program includes TIMSS as one of the international assessments used as a key performance measure to provide data on the progress of Australian school students toward achieving the National Goals for Schooling. The inclusion of international assessments in the National Assessment Program is considered important, not just for benchmarking against other countries, but also for the contextual information provided. The information from international assessments, such as TIMSS, has highlighted some areas of concern for Australia that government policy is currently focusing on. For example, analyses have indicated the need to improve educational outcomes for Aboriginal and Torres Strait Island youth and disadvantaged young Australians, especially those from low socioeconomic backgrounds. In addition, TIMSS (particularly the video study) was used to help guide the development of the new Australian Curriculum.[28]

At the state and territory level, TIMSS is similarly used to evaluate student progress across the system. As a result, TIMSS has played an important role in informing curriculum development and benchmarking, determining the support teachers may need in their mathematics and science teaching, justifying funding support for mathematics and science programs, and prompting further in-depth research into issues raised in the TIMSS data. For example, in South Australia, TIMSS data was used to underpin the Primary Mathematics and Science Strategy for South Australian schools.[29] In some cases, TIMSS results have prompted major system-wide review, such as the Queensland Education Performance Review 2009.[30] Lastly, the TIMSS video study has been particularly useful for pre-service teacher education and training and for in-service teacher professional development. For example, "Lesson Study" as a mode of professional learning was developed in New South Wales as a result of the TIMSS video study and has been used in both secondary schools and primary schools since 2002.[31] Furthermore, a detailed curriculum analysis of high performing countries also has influenced the introduction of specific teaching practices, such as the use of tape diagrams from Japan.

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Austria[a]

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Introduction

Overview of the Education System

Austria is a federal parliamentary republic consisting of nine provinces (*Bundesländer*), each of which has its own provincial government. Responsibility for legislation and its implementation is divided between the federation (*Bund*) and the provinces.

The Austrian education system is hierarchically organized, highly centralized, and selective at a very early stage. The Federal Ministry for Education, Arts, and Culture is responsible for primary and secondary education as well as for the University Colleges of Teacher Education (*Pädagogische Hochschulen*). Its supervisory responsibilities include all areas of school management, organization of school instruction in public and private schools, and remuneration and retirement of teachers employed by the Federal Ministry. However, the Federal Ministry for Science and Research is responsible for universities, including Universities of Applied Sciences (*Fachhochschulen*).

The provinces have legislative responsibility for kindergarten and for providing public-sector compulsory education. They support local communities in establishing and maintaining these schools via school construction funds, which they administer themselves. Each of the nine provinces has a complement of provincial school inspectors, assisted by district school inspectors for compulsory schools and subject inspectors for upper secondary schools.

Preprimary education is available to children up to six years of age (*crèches*, kindergartens, and private child-caregivers). Since 2010, one year of kindergarten at age 5 has been compulsory for all children. This is the last year before they start attending primary school.

Starting with primary education in *Grundschule* or *Volksschule* at age 6, education is compulsory for nine years. *Grundschule* or *Volksschule* encompasses

a Portions of this chapter are based on Austria's chapter in the PIRLS 2006 Encyclopedia, written by the Federal Ministry for Education, Arts, and Culture, as well as on the TIMSS 2007 Encyclopedia, written by the Federal Ministry for Education, Arts, and Culture and the Austrian National Research Center.

Grades 1–4 (ages 6–10).[b] Parents may ask for earlier admission to school if the child's sixth birthday falls before March 1 in the following calendar year, provided that they are mature enough for schooling and have the required social competence for attending school. Six-year-old children considered insufficiently mature to go to school must attend pre-school for one year before beginning primary school.

At the lower secondary level, students and their parents can apply for entry to either a general secondary school (*Hauptschule*), a lower level academic secondary school (*Allgemein bildende höhere Schule—Unterstufe*), or New Secondary School (*Neue Mittelschule*). All these school types include Grades 5–8 and cater to children ages 10–14. The New Secondary School started as a school project in 2008 by combining the elements of academic secondary school and general secondary school to provide a joint school for all ten- to fourteen-year olds. A central feature is the broad implementation of a new learning culture based on individualization and inner differentiation.[1] Students are taught the lower level academic secondary school curriculum by teachers of both school types (general and academic secondary school). At the end of 2011, the government decided that all general secondary schools will be converted into New Secondary Schools by 2016. Ten percent of academic secondary schools may, on a voluntary basis, also change into New Secondary Schools.

Students with special educational needs are taught either in special schools or in inclusive settings at primary and lower secondary (general and academic) schools.[2] Special schools consist of Primary Level I (2 years), Primary Level II (2 years), and Secondary Level (4 years).

Beginning at age 14, students can choose among a variety of different upper secondary schools, including between the following:

1. Pre-vocational school, which lasts only one year (final year of compulsory schooling, Grade 9); and
2. Technical/vocational school, which lasts from one up to four years.

After completing Grade 9, students also may start apprenticeship training by attending a part-time vocational school. In addition, students can receive a matriculation certificate (*Reifeprüfungszeugnis*) allowing access to higher (tertiary) education from several school types:

3. Upper level of academic secondary school (4 years, Grades 9–12);
4. Higher vocational and technical college (5 years, Grades 9–13); and

b Normally, children attend *Grundschule* or *Volksschule* from Grades 1–4. However, there are a few school locations where *Volksschule* also includes upper-primary Grades 5–8.

5. Schools for kindergarten school teachers and educators (5 years, Grades 9–13).

Curricula at the upper secondary level depend on the type of school.

Higher education starts at age 18 or 19. Many institutions, including public and private universities, offer tertiary education programs in a range of subjects and specialties.

An important educational initiative in Austria is IMST. The initiative was previously called Innovations in Mathematics, Science, and Technology, but since German recently has become part of the project it has been renamed *Innovationen Machen Schulen Top* (Innovations to Make Top Schools). Originally, IMST was established as an immediate reaction to the TIMSS 1995 results for upper secondary schools and given the task of analyzing these results. Today's goal is establishing and embedding a culture of innovation in Austrian schools to improve teaching in mathematics, natural science, computer science, engineering, and German. IMST provides subject-related, organizational and financial support for network projects as well as for thematic teacher projects. For example, the Austrian Educational Competence Centers for mathematics, German, biology, chemistry, and physics derived from IMST.

Additionally, three regional subject didactic centers (Graz, Vienna, and Lower Austria[c]) implement subject-specific pedagogical activities. The ministry has a platform for teachers in lower secondary level (not restricted to mathematics) providing support in their daily professional life. The University of Vienna also offers a number of teaching aids for mathematics (www.mathe-online.at). With the introduction of regular mathematics assessments of national educational standards starting in 2012 (Grade 8) and 2013 (Grade 4), there are many teacher training courses or seminars on competency-based teaching in mathematics in primary and lower secondary level.

Regarding science, Austria has few engineers and technicians, especially university graduates.[3, 4, 5] Part of the demand is met by graduates of higher vocational and technical colleges, which are very popular, highly regarded in Austrian society, and therefore attract many students. However, these students are mainly male, thus resulting in a lack of women in scientific jobs. Furthermore, immigrants have shown only minimal participation in science careers. In order to improve equality of opportunity, a number of political initiatives have focused on involving more women and immigrants in technical careers. Corresponding (ongoing) projects include *FIT—Frauen in die Technik*

c For more information, see Regionales Fachdidaktikzentrum Mathematik und Geometrie in Graz (http://mug.didaktik-graz.at), Regionales Fachdidaktikzentrum Mathematik Wien (http://rfdzmathematik.univie.ac.at), or Pädagogische Hochschule Niederösterreich (http://rfdz.ph-noe.ac.at).

(Women into Technology[d]), *fForte—Frauen in Forschung und Technologie* (Women in Research and Technology[e]), and *Promise—Promotion of Migrants in Science Education*.[f] The former project *mut!—Mädchen und Technik* (Girls and Technology) concluded in 2010. In addition to these projects, many companies and public institutions participate in annual Girls' Day, where girls can visit companies working in engineering and technology.

The Science Center Net association works to improve the understanding of science in Austria by providing numerous special activities for schools and science teachers. Many museums have been involved, creating special science zones where people can conduct experiments. The idea of special science museums with hands-on experiments is relatively new in Austria.[g]

Another innovation is the Sparkling Science project, initiated by the Federal Ministry for Education, Arts, and Culture. Universities and schools are working together on various projects in different disciplines to promote science at an early age.[h]

Austria also participates in the European project Science on Stage to expand a network of science teachers and bring new ideas into science teaching. People of all ages from schools, universities and engineering present their experiments and work at an international festival.[i]

Languages of Instruction

Austria's official language is German, with Slovene, Croatian, and Hungarian as official languages in some districts with mixed languages in the provinces Carinthia and Burgenland.[j] German is also the language of instruction, except in districts with mixed languages. In these districts, primary school lessons are bilingual (German and either Slovene, Croatian, or Hungarian must be used equally in instruction).[6] At the lower secondary level, some general secondary schools have Slovene as a compulsory subject and there is one Slovene secondary academic school in the country.

d For more information see: http://www.bmukk.gv.at/FIT

e For more information see: http://www.fforte.at

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g For more information see: http://www.science-center-net.at

h For more information see: http://www.sparklingscience.at

i For more information see: hattp://scienceonstage.at

j Apart from Slovene, Croatian, and Hungarian, minorities include Czech, Slovak, and Roma.

Mathematics Curriculum in Primary and Lower Secondary Grades

The curriculum for primary education (Grades 1–4) consists of different parts: general educational targets, including the schools' tasks; 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; special educational targets and didactic principles for the different subjects; 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—In this domain, 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 reaches up to 1000 in Grade 3, and up to 100,000 in Grade 4.
- Arithmetic Operations—This domain ranges from learning the concepts underlying the operations to carrying out all four arithmetic operations (addition, subtraction, division, and multiplication), using them to solve real-life problems. In Grades 3–4, the use of arithmetic operations intensifies and the number spectrum becomes progressively larger. Additionally, in Grade 4, students learn about fractions having 2, 4, or 8 as a denominator.
- Quantity—This domain develops understanding of comparing and formulating relationships with different units of measurement (e.g., euro and cent, time, weight, length, area), and applying quantities in different situations. In Grades 1–2, students develop the concept of quantity and learn to apply different units of measurement. The focus in Grades 3–4 is on estimation as well as on measuring, comparing, and transforming units of measurement.
- Geometry—This domain's main targets for Grades 1–2 are the following: observing, ordering, and structuring spatial relationships and shapes; enhancing the ability to orientate; using plotters and making quantitative links. Students investigate and describe simple geometric figures. In Grades 3–4, the focus is on identifying and classifying geometric figures, measuring objects, and using plotters. Students also learn how to calculate circumference, as well as the perimeter and area of rectangles and squares.

All four domains are part of the curriculum for each grade. While the learning targets for Grades 1 and 2 are combined, those for Grades 3 and 4 are separated. In Grade 4, Arithmetic Operations includes fractions.

In lower secondary education (Grades 5–8), the curriculum for the general secondary school and lower level of academic secondary school are almost identical, except a slight difference in grouping students during lessons. In general secondary schools, students are grouped into three achievement levels according to their abilities in German, mathematics, and foreign language (usually English). Students in the highest achievement level must meet the requirements of lower level academic secondary schools. The curriculum for both types of schools differentiates between core and extension domains in subjects mandatory for all students. Two-thirds of instructional time must be devoted to the core domains defined in the curriculum, while one-third may be chosen from extension domains not explicitly defined in the curriculum. It is possible to teach the extension domains using an interdisciplinary approach, with teachers of other subjects.

The core domain for Grades 5–8 in mathematics includes the following subdomains:

- Working with Numbers and Quantity—In Grade 5, this subdomain extends the ability to use natural numbers, and familiarizes students with decimals, fractions, and the rules for the order of arithmetic operations. Students also gain confidence in doing mental arithmetic and using electronic media. Grade 6, is primarily devoted to decimal and fractional arithmetic, in addition to percentages and the use of dimensions. In Grade 7, students illustrate rational numbers relative to zero and learn about a system of coordinates. In Grade 8, students study the reason why arithmetical situations cannot always be solved with rational numbers.

- Working with Variables—In Grades 5–6, this subdomain focuses on formulas and linear equations, as well as on the ability to describe general situations with variables. In Grade 7, students learn to transform formulas, justify these transformations with rules, and solve linear equations with one unknown term. Grade 8 reinforces the work with variables, formulas, and equations, teaches students how to display their work graphically, and covers solving linear equations with two variables.

- Working with Figures and Solids—Students in Grade 5 learn to do the following: recognize and describe geometric figures and solids, and their properties; draw and construct rectangles and circles, calculate the perimeter and area of rectangles as well as volume and surface area of cubes and rectangular solids, and work with angles and symmetric figures. In Grade 6, working with geometric figures intensifies and extends to the following: triangles, quadrilaterals, and regular polygons; and degrees of angles, angle symmetry, and the volume of prisms. The curriculum in Grade 7 includes formulas to calculate the area of triangles and quadrilaterals, the Pythagorean theorem, and the increasing and scaling down of figures. In Grade 8, students learn justifications of the Pythagorean theorem, calculate the circumference and area of circles, and use formulas to calculate surface areas and volumes of pyramids, cylinders, cones, and spheres.

- Working with Models and Statistics—Students in Grade 5 learn to use tables and graphical displays to convey data, compare models with real-life situations, and understand the significance of models. In Grade 6, students calculate relative frequencies and learn 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 investigating and displaying functional dependencies and using statistical key data to display data.

Science Curriculum in Primary and Lower Secondary Grades

Science instruction in primary school is included in the integrative subject *Sachunterricht*, which is divided into the following learning areas: Community, Nature, Space, Time, Economics, and Technology. The subject matter in each of the four primary grades includes all of these learning areas. However, no science content is included in the following learning areas: Community (social structures), Space (regional geography), Time (local history), and Economics. Thus, the total amount of science in *Sachunterricht* is relatively small. The curriculum describes the subject matter for Grades 1–2 combined, and then separately for Grades 3 and 4.

- Nature—This learning area focuses on understanding the environment, as well as on 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, themes are introduced with simple examples. Grade 3 focuses on enhancing these themes, and Grade 4 emphasizes further understanding and application.

- Technology—In conjunction with the school subject handicrafts, this learning area focuses on technical facts in the environment, natural forces and their effects, and substances and their transformation. In Grades 1–2, the subtopic Technical Facts in the Students' Environment relates to mechanical objects such as tools, wheels, handles, and switches. Grade 3 extends this knowledge to the indirect environment, and in Grade 4, it is further enhanced. Students also learn about handling objects and specific operational methods through examining, measuring, and experimenting with objects. The first two grades introduce students to these methods and, in Grades 3–4, this knowledge is extended and enhanced. Specifically, students explore objects by viewing and measuring and conduct their first experiments dealing with facts in everyday life. Water is an omnipresent significant theme throughout primary school, as is responsible use of technical equipment.

Regarding lower secondary education (Grades 5–8), the Austrian school system is divided into two main branches: the general secondary school, and the lower level academic secondary school. However, the science curriculum is completely the same, with at most only minor differences between schools because of different thematic emphases.

Parallel to the mathematics curriculum, the science curriculum also is organized to have a mandatory core domain, which should take two-thirds of the instructional time. The remaining one-third of the time may be devoted to extension domains dealing with topics not strictly defined in the curriculum or intensifying parts of the core domain, such as relating student learning and thinking through situation-oriented education events, different ways of learning (e.g., discovery, project-based), and meaningful linkages of cross-cutting aspects of subjects.

Science is divided into several subjects in lower secondary schools. From fifth to eighth grade, students are taught biology and environmental education as well as geography, including geological topics contained in TIMSS. Students have physics classes in Grades 6–8, and in Grade 8, they also have chemistry. Biology mainly covers human beings and health, animals and plants, and ecology and the environment. Topics include the following:

- Human Beings and Health—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—Structure and function of local animals and plants, specifically vertebrates, spermatophytes, and pets (Grade 5); invertebrates, spermatophytes, cryptogams, fungi, micro-organisms, and cells (Grade 6); useful plants and production animals (Grade 7); and the roles of organisms in urban ecology, and the ecology of other areas (Grade 8).

- Ecology and the Environment—Basic ecological terms; positive and negative effects of human behavior; environmental problems; and protection and conservation, using examples from vertebrates and forest ecosystems (Grade 5); forest ecosystem and national water ecosystems (Grade 6); land ecosystems and agricultural ecosystems (Grade 7); and urban ecology and ecosystems of other areas (Grade 8).

Geography and economics in Grades 5–6 cover the diversity of human life and economies on Earth while teaching basic skills and comprehension through simple examples. Using globes and maps, students learn about the lives and economies of people in different areas, reactions to natural disasters, use of natural resources and energy, economic systems and climatic conditions, living in urban communities, production of goods in industrial and commercial enterprises, fields of services, and the Earth as a living and economic area. In Grades 7–8, these areas are extended and enhanced.

Physics in Grades 6–8 gives students a general understanding that should be applied to concrete situations by examples. The curriculum consists of single modules, which can be used in a different chronological order, as well as for different emphasis. The modules for Grades 6–7 are the following:

- Physics Determines Our Life—Physical thinking and the difference between physical and nonphysical thinking.

- The World in Which We Are Moving—Procedures hindering or supporting movement, including force, mass, inertia, weight, and friction.

- All Solids Consist of Particles—The particle model and its effects on solid properties, such as the structure of solids, and heat phenomena; the development and dispersion of sound; and swimming, floating, and falling of solids in water.

- The Dream of Flying—Flying and the principles of aerodynamics.

- Our Life in a Warming Bath—Thermal activity in the living and inanimate world; heat conduction, heat flow, and heat radiation for understanding of global or local weather.

- Electrical Phenomena Are Omnipresent—Electrical procedures in everyday life; nature as electrical potential; and current and resistance.
- Making Things Possible through Electrical Engineering—The construction and effects of electrical equipment; the importance of safety; and economic measures.

In Grade 8, physics modules include the following:

- Electricity Determines Our Life—Technical production and consumption of electrical energy.
- The Visible World—Formation and dispersion of light.
- Curved Pathways on Earth and in Space—The effects of forces and the movement of objects.
- The Radioactive Reaction of Material—Procedures in the atomic nucleus.

Chemistry is taught as a special subject in Grade 8 and includes the following topics:

- Classification and characteristics of materials;
- The principles of material construction (e.g., particle and atom model);
- Basic patterns of chemical reaction (e.g., attributes and reaction of acids and bases);
- Sources of raw materials 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

Based on proposals drafted by curricular task forces, the Federal Ministry for Education, Arts, and Culture establishes a curricular framework through a consultation process, which includes district and provincial educational bodies and teacher associations. The schools have some measure of freedom to adapt the curriculum to local needs. The curriculum provides a joint guiding framework that lays out the general overarching aims. The curriculum itself states that teachers have pedagogical and didactical responsibility to freely select methods. Teachers also have some freedom in selecting teaching materials.

Instructional Materials, Equipment, and Laboratories

Instructional materials are not part of the curriculum published by the Federal Ministry for Education, Arts, and Culture. A list of approved materials (textbooks) exists for each grade level but none are explicitly recommended. Textbook approval lies with a commission at the ministry. Under the *Schulbuchaktion* (school book initiative), students receive textbooks on the approved list in addition to other materials free of charge (up to a financial limit).

Although laboratories and equipment for teaching science are practically non-existent in primary schools, they are more common at the lower secondary level. Almost every secondary school has a science lab.

Use of Technology

The second part of the primary school curriculum ("General Provisions") states that communication and information technologies should be used according to availability. They should be employed in order to learn independently and individually. Neither the science nor mathematics curriculum mentions computers (or IT).

Calculators are not mentioned in either the mathematics or science curriculum through Grade 4, however the mathematics curriculum for Grades 5–8 includes a statement that electronic devices should be used when solving mathematical problems. Although the curriculum allows calculator use beginning in Grade 5, most Austrian lower secondary schools begin systematic use of calculators in Grade 6 or 7.

In the science subjects, computer use is explicitly stated for biology and chemistry, but not physics. However, the general educational goals of the curriculum include a passage explaining that computer-based sources of information should be provided in all subjects.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Usually students have individual teachers for mathematics and science beginning in Grade 5. Specifically in science, specialist teachers teach the following subjects: biology and environmental education, physics, chemistry, and geography.

Homework Policies

The legislative regulation of homework is part of the *Schulunterrichtsgesetz* (School Instruction Act). This document states that homework may be given to complement work within the lessons.

In primary school, it is common to assign homework in mathematics, but quite seldom in science. The same is true for lower secondary education; regular homework in mathematics is usually given, while homework in science is rare.

Teachers and Teacher Education

Teacher Education Specific to Mathematics and Science

Admission to a teacher education program requires a general higher education entrance qualification obtained through the upper secondary school leaving examination (matriculation certificate)—the same as for university admission. There are two main streams of teacher education in Grades 1–8:

- Primary school teachers and general secondary school teachers are educated at University Colleges of Teacher Education (*Pädagogische Hochschulen*). Since 2007–08, this six-semester (3-year), higher education program has concluded with a bachelor degree in education.
- Academic secondary school teachers are educated at universities for nine semesters (4.5 years) leading to a master's degree.

Currently, these two separate paths of teacher education are undergoing intensive discussion in Austria, with a view toward reforming the structure and the contents of the programs.[7]

In addition to completing their education, teachers for primary and general secondary schools complete a supervised practicum in each of the six semesters. They observe and practice teaching under the supervision of experienced teachers and attend training at seminars as an essential part of their education. If students receive two successively negative reports, they are not allowed to continue their education. Upon successful completion of a bachelor's thesis and the final state examination, teachers obtain a qualification certificate.

Primary school teachers are general-purpose teachers who usually teach almost all subjects of the primary school curriculum. There are no specialized mathematics and science teachers in primary school.

Teachers in general secondary schools train in two subjects, with students choosing a first subject (German, English, or mathematics) and a second subject from other compulsory subjects, also including science subjects (physics/

chemistry, biology, or geography). Most commonly, however, teachers are assigned more subjects in practice than the two in which they were trained.

Academic secondary school teachers also complete coursework in two disciplines, in addition to other educational courses. Science-related subjects include biology, chemistry, physics and geography. During their education, they also must complete a supervised practicum, whose duration varies from university to university.

A master's degree does not fully qualify a teacher for employment. University graduates must complete a second phase in their education—a probationary teaching period of one year. In the course of this part of their education, they teach at school with a reduced teaching load, supervised by a specially trained teacher, and they attend complementary seminars (including school legislation, school education, general didactic and didactic for those subjects they have chosen for their education) at a University College of Teacher Education.

Requirements for Ongoing Professional Development

Professional development primarily is offered at University Colleges of Teacher Education. Primary and general secondary school teachers must attend 15 hours per year of professional development activities. No national statute regulates the courses they must complete; teachers may choose on their own from a variety of courses in different fields such as music, physical education, media, science, or school management. Professional development addresses topics that are not or only partially covered in education studies, and range from short one-day courses to courses over several semesters. There is no compulsory professional development for teachers of academic secondary schools.

Monitoring Student Progress in Mathematics and Science

In Austria, no formal external testing occurs during compulsory education that has consequences for individual students; only teachers assess student performance. Teacher-generated assessment is based on classroom participation as well as on the results of oral, written, practical, and graphical work. Primary school students take written examinations (school tests) in German and mathematics in Grade 4. In lower secondary schools, students are required to pass classroom exams in German, mathematics, and the first foreign language (most commonly English). As a rule, progression to the next educational level depends on achievement in all subjects. Students receive reports at the end of each term and at the end of the academic year.

In 2009, the Austrian government mandated educational standards based on the core curriculum for "German, reading, writing" and mathematics in primary school and German, mathematics, and English in secondary school. For these subjects, the Austrian Educational Standards determine the basic competencies students normally should have acquired by the end of Grade 4 (primary school) and by the end of Grade 8 (secondary school). The standards aim to strengthen teacher output-orientation regarding planning lessons as well as conducting the lessons themselves. Furthermore, the standards provide a benchmark for student competencies with regard to diagnostic and individual support. The Educational Standards are required to be fully assessed throughout the nation in a three-year cycle. This mandated regular assessment is intended to foster the development of quality within individual schools and to enable review of the efficiency of the education system (system monitoring). Therefore, teachers and schools receive external feedback about testing results. Specialists support the schools by interpreting the results and devising specific strategies for each school. Although the standards are objectives for teachers and are therefore incorporated when teaching and grading students, the results of the Educational Standards Assessments must not influence student grades.

At the eighth grade, the first nationwide Educational Standards Assessment in mathematics took place in 2012 (English will follow in 2013, and German in 2014). At the fourth grade, the Educational Standards in mathematics will be assessed for the first time in 2013, followed by "German, reading, writing" in 2014. Baseline tests were conducted in 2009 (secondary schools) and 2010 (primary schools) with a random sample of schools in order to attain data about the actual state of the acquired competences at the beginning of the process.

Impact and Use of TIMSS

Austria participated in TIMSS 1995, 2007, and 2011. As described above, the initiation of IMST was an immediate reaction to the results for students in upper secondary level in TIMSS 1995.

Following TIMSS 2007, Austria published four national reports (Technical Report, Study Description, First Results, and Experts Report). The two releases of the reports included results, each accompanied by a press conference. In addition, a symposium was held focusing on issues raised in the Experts Report, and was attended by educational researchers, educational policymakers, and other interested members of the educational community. Although BIFIE offered lectures about the results of TIMSS for schools, teachers and University Colleges of Teacher Education, the lectures have (in contrast to PIRLS) not been made use of. One possible explanation might be that reading is, especially in primary school, a more important and sensitive domain than mathematics and science. Alternately, mathematics and science confront both teachers and students with a rather complex set of challenges.

Austria is also participating in PIRLS and PISA, and participated in TALIS 2008 (Teaching and Learning International Survey). Each of these studies has highlighted weaknesses in Austria's education system, and the data have made evident the need for reforms, some of which have already been implemented. The New Secondary School, a compulsory year of kindergarten for all five-year-olds, the Educational Standards, and the standardized school leaving examination (Standardisierte Reifeprüfung) are among the encouraging changes to date.

Suggested Readings

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Azerbaijan

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Introduction

Overview of the Education System

The education system in the Republic of Azerbaijan operates in accordance with numerous laws and legislative acts: the Constitution of the Republic of Azerbaijan; the 2009 Law of the Republic of Azerbaijan on Education; respective educational decrees, orders, and decisions; Ministry of Education regulations; other normative legal acts relating to education; and international agreements.[1] The constitution guarantees every citizen the right to education and the government guarantees free obligatory primary and secondary education.[2, 3] The government oversees the education system, which is secular, while the President and Cabinet Ministers determine education strategy, supervise implementation of the Law on Education and relevant legislative acts, and define regulations for establishing, restructuring, and closing higher education institutions.[4, 5] The cabinet also can establish, restructure, and close vocational institutions as well as approve qualifications, educational regulations, and rules for these institutions. In addition, the cabinet makes certain proposals on budget development and defines national standards for educational funding, scholarship regulations, and salary payment.

The Ministry of Education of the Republic of Azerbaijan is the central executive body that implements and regulates government education policy, and manages the educational process. The ministry cooperates with central and local executive bodies, local authorities, international and non-governmental organizations, other individuals, and legal entities.[6] The ministry centrally oversees education, but works jointly with relevant departments in managing the following:

- Organizing mental health services and social or pedagogical care;
- Studying and disseminating advanced pedagogical practice and achievements in pedagogical and psychological sciences;
- Identifying and developing talented students;

- Promoting innovative methods for teachers, heads of school, and educational staff; and
- Strengthening the educational and material foundation of schools and education institutions.

Educational institutions in the Republic of Azerbaijan are classified as state, municipal, or private, according to property type.[7] The education system encompasses all educational institutions and includes the following:

- Entities engaged in educational activities and training;
- Scientific-research institutes developing educational activities;
- Sports and health complexes;
- Information centers, libraries, campuses, camps, hostels, and cultural-educational institutions and organizations; and
- Non-governmental organizations, associations, societies, councils, and other entities acting in the education field.[8]

The educational system is based on national and universal values. The basic principles of public policy in the educational sphere are the following: humanism; democracy; equality; nationalism and cosmopolitism; quality; rationality; continuity, unity, and consistency; liberalization; and integration.[9]

The Law on Education was first established in 1992, and the new Law on Education was adopted in 2009. The new law takes into consideration the social and political changes occurring in the country and the educational reforms that the ministry has implemented and continues to put into practice. The law generally conforms to the principles of the Bologna process (e.g., a three-cycle higher education system) and applies relevant modifications and improvements to all legislative acts, regulations, and rules. According to the updated Education Law, general primary and secondary education is compulsory and provided free of charge in state educational institutions.[10]

The 2009 Law of the Republic of Azerbaijan on Education establishes scientific and pedagogical councils as higher governance bodies in public educational institutions.[11] Exhibit 1 presents the stages and levels of education dictated by the Law on Education.

Exhibit 1: The Stages and Levels of Education

Stage	Description
Preprimary	Preprimary Education—This stage is for children from birth to age 5 or 6 and is not compulsory. It is provided in nurseries (children under age 3), kindergartens (children ages 3–5 or 6), and nursery-kindergartens.
General Education	Primary Education (Grades 1–4)—This level is for students ages 6–10 and is compulsory.
	General Secondary Education (Lower secondary education, Grades 5–9)—This level is for students ages 10–15 and is compulsory. At the end of Grade 9, students take final assessments to receive appropriate documentation to continue to the next educational level.
	Complete Secondary Education (Upper secondary education, Grades 10 and 11)—This level is for students up to the age of 17 and is compulsory. Completion of this stage results in the Certificate of Complete Secondary Education.
Initial Vocational Education	Initial Vocational Education—The duration of programs is two years for Grade 11 graduates and four years for Grade 9 graduates. Students who have completed secondary education can also enroll in two-year initial vocational education programs leading to a diploma.
Secondary Vocational Education	Secondary Vocational Education— Admission to this stage requires passing the examination administered by the State Commission on Student Admission. This stage is provided by colleges and higher educational institutions, and results in a bachelor's degree. Students admitted into secondary vocational schools following general secondary education institutions receive complete secondary education.
Higher Education (including universities, academies, institutes, colleges, and conservatories)– Admission to higher education is based on the results of the national admission test administered by the State Commission on Student Admission.	Baccalaureate—Graduates of the Baccalaureate level have completed higher education and receive a bachelor's degree, the highest degree of professional qualification. The duration of programs leading to the bachelor's degree is normally four years.
	Master's—At the postgraduate level, the duration of master's degree programs is two years.
	Doctorate—The duration of programs leading to the degree of Doctor of Philosophy or Doctor of Science (introduced by the 2009 Education Law) is three to four years. In the previous system, the duration of programs leading to the degree of Candidate of Science was three years; the degree of Doctor of Science required at least an additional three years of study and supervised research.[12]

Languages of Instruction

According to the Constitution of the Republic of Azerbaijan, the official language of the country is Azerbaijani, and according to the 2009 Law of the Republic of Azerbaijan on Education, the Azerbaijani language is the language of instruction.[13] In general, instruction in educational institutions also is provided in other languages, based on national education standards, depending on the wishes of citizens and institutions' founders, with compulsory teaching in Azerbaijani language, literature, history, and geography.[14] At present, instruction at general educational institutions of the Azerbaijani Republic is in Azerbaijani, Russian, and Georgian.[15] In primary school, children of minorities have the opportunity to learn the Talish, Avarian, Lezgian, Hebrew, Sakhur, Khinalig, and Udin languages as separate subjects along with the Azerbaijani language.

The Azerbaijani Curriculum in Primary Schools

A new curriculum was introduced in the 2008–09 school year, but was not implemented in the fourth grade until the 2011–12 school year. Thus, the students participating in TIMSS 2011 did not receive instruction under the new curriculum. The new curriculum is substantially different from the 2002 curriculum, which was based on educational standards approved by the Cabinet Ministers.[16] For example, the new mathematics curriculum addresses mathematics in real-life contexts and the previous science curriculum has been replaced with a Life Skills curriculum.[17, 18]

Mathematics Curriculum in Primary Grades[19]

The fourth-grade mathematics curriculum includes the following topics and activities:

- Numbers within 1,000,000 and Symbols—Naming, calculating, and writing numbers up to one million; values of numbers; describing numbers as a sum of two or more addends; comparing numbers, units of length (kilometer, meter, decimeter, centimeter, and millimeter), and converting among them; units of mass (ton, kilogram, and gram) and converting among them; units of time (year, month, week, day, hour, minute, and second) and the relationships between them; describing points, line segments, and polygons with letters; and finding perimeters of right triangles using Pythagorean triples.
- Addition and Subtraction—Generalization and systematization of addition and subtraction; addition and subtraction of numbers up to one million with answer checking; addition with grouping; relationships among the terms and difference in a subtraction problem; and solving simple equations using addition and subtraction with answer checking.
- Multiplication and Division—Generalization and systematization of multiplication and division; distributive and associative properties of multiplication; multiplication as repeated addition, and division as repeated subtraction; relationship between multiplication and division; solution of simple equations using multiplication and division with checking; written multiplication and division with one-, two-, and three-digit numbers; division with a remainder; fractions; calculating with percentages; introduction to the concept of area and units of

area (mm^2, cm^2, dm^2, m^2, km^2, and hectare) and conversions among them; dependences between and among speed–time–distance and cost–quantity–value; areas of squares and right triangles; and order of operations with and without brackets.

Science Curriculum in Primary Grades

The fourth-grade science curriculum consists of several units, which are listed below with some examples of topics and activities corresponding to each:

- Introduction: How Do Humans Learn About Their Surroundings?—Practical activities, including measuring the mass and temperature of a liquid; measuring length and area; and measuring air temperature.
- The Local Territory and Its Description—Horizon, horizon line, and plans and maps.
- The Nature of the World—Earth's strata; features of the Earth's surface (e.g., plains, hills, mountains, valleys, and ravines); natural divisions of the Earth; and excursions to allow students to become acquainted with fields, meadows, and forest plants and animals.
- The Human Body and Health—The structure of the human body; blood and the circulatory system; the respiratory system; sensory organs; the digestive system; the nervous system, the spine, and the brain; and cleanliness and health.
- Nature Use and Conservation.

After completing the science curriculum, fourth-grade students should know the following:

- Some natural features of the local area (e.g., rock strata, soils, minerals, water basins, plants, and animals), and changes in the weather due to seasons;
- Features (e.g., buildings, landfills, and bridges) constructed in the local natural environment;
- The meaning of horizon, the poles, lines of latitude and longitude, and how a compass works and how to use one;
- Some physical properties of local mineral products, physical properties of water and water quality (e.g., solutions, color, taste, cloudiness, flow rate, and sources), and the structure and properties of local soil, including composition (e.g., clay, sand, mineral salts, and humus) and amount of moisture;

- The names of several plants growing in forests, fields, lawns, and water basins; and the names of several animals living in these habitats;
- Common ways to protect one's health, the state healthcare system, and the role of doctors;
- The roles of the human body systems (e.g., nervous, respiratory, and digestive); and
- The importance of water, weather, the sun, and the plant world to human life.

Students also should have acquired skills at the completion of the fourth grade that enable them to do the following:

- Find the poles with the help of a compass and the sun;
- Identify properties of water and soil;
- Make scientific observations and record them;
- Read physical maps;
- Follow safety rules during excursions and experiments;
- Care for plants; and
- Take an active part in nature conservation.

Instruction for Mathematics and Science in Primary Grades

In the first stage of secondary education (Grades 1–4), mathematics instruction is allocated four 45-minute periods per week.[20] Science instruction is taught as Environmental Studies in Grades 1 and 2 and as Natural Sciences in Grades 3 and 4, and is allocated two 45-minute periods per week.

Instructional Materials, Equipment, and Laboratories

The Ministry of Education provides instructional materials free of charge for all government schools, and students in every class and educational stage receive free textbooks, which comply with the framework of the approved curriculum.

Use of Technology

The 2002 curriculum for primary education (Grades 1–4) only generally recommends that computers be used for learning and creative work in mathematics and science.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Students have specialist teachers for mathematics and science starting in fifth grade. Primary-level classroom teachers usually teach all subjects (with the exception of music and sports).

Homework Policies

There is no official regulation regarding homework. Homework is assigned at teachers' discretion and is a common practice in primary education.

Teachers and Teacher Education

Graduates of secondary and vocational schools or colleges must have relevant diplomas of completion (or Certificates of Secondary Education) to apply to tertiary teacher education programs. Admission to these programs is based on central examinations administered by the State Student Admission Commission of the Republic of Azerbaijan. The ministry also approves a list of bachelor's degree specialties (programs) in higher education.[21]

At the pre-service level, at least 40 percent of teacher education program content covers subjects related to psychology and pedagogy. Practical training in general secondary schools also is provided as a component (at least 18%) of the program.[22]

The State Education Standard Structure defines the study program for specialties at the bachelor's level with minimum mandatory requirements for the content and level of bachelor's degree preparation.[23] In 2009, the Cabinet Ministers added education as a specialty to the list of bachelor's degree programs.[24] Generally, bachelor's degree programs for primary school teachers last four years, with curricula allocating 198 total weeks of study.[25] These curricula include 465 hours for general subjects, 660 hours for subjects related to general professional training, 1,875 hours for speciality subjects, and 18 weeks of teaching practice. Specifically, the 1,875 hours of specialty subjects include the following: elementary mathematics (240 hours); elementary mathematics teaching methodology (120 hours); informatics and its teaching methodology (105 hours); life skills and its teaching methodology (120 hours); and human anatomy, physiology, and hygiene (60 hours).[26]

After completing a Fundamentals of Elementary Mathematics course, prospective teachers are expected to be able to do the following:

- Understand the objectives and duties, contents, and fundamental features of elementary mathematics taught in primary education, and align them to the school curriculum;
- Guide the formation of students' skills for working with simple functions, equations, and inequalities;
- Know the main concepts of arithmetic logic, numbers, and geometric figures and be able to incorporate them into instruction in the primary grades (Grades 1–4);
- Know how to use and teach the concepts of magnitude as a method for formulating the concept of operations on natural numbers;
- Teach arithmetic operations on natural numbers up to one million;
- Incorporate mathematics into students' (simple) daily life experiences;
- Present geometric figures, explain their definitions, properties, and measurements, and indicate their correspondance to common signage; and
- Use simple mathematical approaches in instruction for other subjects.

After completing an Elementary Mathematics Instructional Methods course, prospective teachers are expected to be able to do the following:

- Apply appropriate instructional methods and tools to mathematics education in the primary grades, and organize instruction;
- Know the required level of mathematical preparedness for students in each grade;
- Evaluate students' mathematics knowledge, skills, and habits in the primary grades;
- Have the knowledge and skills to approach mathematics teaching consciously and creatively;
- Use differentiated instruction when teaching arithmetic content and concepts;
- Work with different information sources and use them effectively in the instruction process; and acquire new knowledge independently, make deductions, and generalize from the new knowledge; and
- Anticipate students' thinking style about mathematics and adapt teaching to respond.

After completing a Life Skills and Its Instruction Methodology course, prospective teachers are expected to be able to do the following:

- Have the necessary knowledge of national symbols, social progress, economic progress, population, resources, museums and monuments, significant people, nature, climate of the country, events that occur in nature and society, and the foundation of natural sciences and other topics;
- Have knowledge of the appropriate instructional processes to teach the subject;
- Compare events occurring in nature and analyze and define laws governing natural phenomena;
- Behave according to a high moral standard;
- Have skills and attitudes appropriate to instilling values in students; and
- Know how to conserve nature.

After completing a bachelor's degree program in primary or secondary education, prospective teachers obtain diplomas of pedagogical education from their respective higher education institutions. The State Final Graduate Attestation Committee confers this professional qualification with approval from the Ministry of Education of the Republic Azerbaijan. Graduates can apply for admission to post-graduate studies based on their results on entrance examinations set by the State Student Admission Commission of the Republic of Azerbaijan and corresponding to their area of study at the bachelor's level. In 2010, the Cabinet Ministers approved the content and organization of a master's degree in education as well as procedures for conferring the degree.[27]

Requirements for Ongoing Professional Development

Currently, in-service teacher education in Azerbaijan is carried out in four stages: teacher professional development in their field of practical activity (2 months); training and development of teachers in science and research activities; re-training for those with a specialization in non-teaching professions; and short-term pedagogical education programs (1–2 weeks) to enhance degrees and levels of education.

According to Cabinet of Minsters' Decree 102, the "conception and strategy of continuous education and teacher training" specifies that, every five years, teachers should participate in 120 hours of professional development via three modules.[28] Module I (30 hours, 5 credit points each) is general professional development in educational foundations, including new skills development, pedagogical psychology and sociology, judicial fundamentals of education, and new pedagogical thinking. Module II (60 hours, 10 credit points each) is professional development in a specialty field for subject-related education, including the development of new skills in methodology, didactics, implementing new curricula, and using ICT. Module III (30 hours, 5 credit points each) is professional development on innovations and new trends in education, including new skills development and innovative pedagogical techniques and teaching methods.[29]

Monitoring Student Progress in Mathematics and Science

The framework of the 2003 education reform implemented a new assessment system; the Ministry of Education administered final assessments in Grades 9 and 11 in comprehensive schools and determines the day, time, subjects, and the numbers of questions for final examinations in each subject every year.[30] Furthermore, beginning in the 2005–06 school year, final examinations in comprehensive schools for complete secondary education were experimentally centralized. Since the 2008–09 school year, all students in the final grade of complete secondary education (Grade 11) take centralized final examinations and, since the 2009–10 school year, all students in the final grade of general secondary education (Grade 9) also take centralized examinations in mother tongue and mathematics. In the 2011–12 school year, the centralized examinations for Grades 9 and 11 were administered by the State Students Admission Commission. Students of both grades were examined in mother tongue and mathematics.

Student achievement is graded on a scale of 1–5 and recorded in general secondary school registers. Semiannual and annual grades are based on daily grades. From the 2012–13 school year, the new assessment rules used in primary education since 2008 will be applied in general secondary education (Grades 5–9). The new school-based assessment is composed of a diagnostic component (initial), formative components (tracking of progress and failure), summative components (small, large, and final), and curricular components used by education governing bodies to confirm that student achievement conforms to curriculum standards.[31]

Teachers mainly conduct diagnostic assessments to provide individualized instruction, define teaching strategies, and, when necessary, collect information about students' knowledge and skills. Teachers collect this information on student knowledge and skills at the beginning of the school year, when beginning new units and topics, or when students have transferred from other schools or classes. The results of these assessments are recorded in official documents:[32] formative assessment results are recorded in the formative assessment register and students' record books;[33] and summative assessment results are recorded in the class register. Teachers perform small summative assessments upon completing units and topics in class, and consider these results when calculating semiannual grades.[34]

Primary school students are retained at the same grades in exceptional cases, such as long-term illness. Secondary-school students in grades with no final assessments are promoted from class to class based on positive annual grades (satisfactory, good, and excellent).[35] Students with failing annual grades in one to three subjects are assigned remedial work over summer vacation. Students with failing annual grades in four or more subjects who do not successfully complete their summer remedial work are retained at the same grade level.[36]

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Bahrain

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Introduction

Overview of the Education System

In the Kingdom of Bahrain, Article 7 of the Constitution guarantees education and cultural services to all citizens, and stipulates "education is free of charge in basic and secondary public schools."[1] As legislated by Article 6 of the Education Law, the first nine years of basic education are compulsory for all children ages 6–15.[2]

In Bahrain, public schools are run by the Ministry of Education (MoE), the official body responsible for implementing the kingdom's policies in education.[3] The government and private sector share management of the following educational stages:

- Nursery school education (ages 1½–3) is run by the private sector, under the supervision of the Ministry of Human Rights and Social Development, which was newly established in 2011 upon royal decree.[4]
- Preschool education (ages 3–5) includes kindergartens run by the private sector under MoE supervision. This stage of the education system is not mandatory.
- Basic education (ages 6–15) includes three school cycles within two stages: primary and intermediate. The primary stage comprises the first cycle, Grades 1–3, and the second cycle, Grades 4–6. The intermediate stage comprises the third cycle, Grades 7–9. Students must successfully complete the last year of the second cycle to continue to the third cycle.

Private educational institutions comprise nurseries, kindergartens, private schools, colleges, and educational centers.[5] Private schools differ according to education levels offered and the policies and educational bodies they follow. However, these schools are not independent, and they are obligated to use curricula and textbooks approved by the ministry. In 2011, there were 73 private schools, along with 44 nurseries and 133 kindergartens.[6, 7, 8]

A portion of MoE's annual budget is allocated for mathematics and science education, including expenses for translating textbooks, teacher training, and operating the TIMSS national office in Bahrain. In 2010, MoE's budget was 225,020,000 Bahraini dinars.[9]

Languages of Instruction

The official language of Bahrain is Arabic and it is the language of instruction in all 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, French, or Arabic.

The Bahraini Curriculum in Primary and Lower Secondary Schools

The mathematics and science curriculum in use for the Bahraini students assessed in TIMSS 2011 was the translated McGraw Hill curriculum. This curriculum is a new curriculum in Bahraini schools and recently was implemented through the secondary level in the following stages: Grades 1–3 in 2009, Grades 4 and 7 in 2010, Grades 5 and 8 in 2011, and Grades 6 and 9 in 2012. The curriculum is built upon two domains: the content domain and the cognitive domain (i.e., skills and behavior). Within these domains, content areas and topic areas detail the competencies that students should achieve by particular grade levels.

Mathematics Curriculum in Primary and Lower Secondary Grades

The mathematics curriculum for fourth grade students in Bahrain covers five content areas: Numbers and Operations, Algebra, Geometry, Measurement, and Data Analysis.[10] Each content area contains topic areas that are well defined, and include mathematical knowledge of concepts, facts, and procedures. In addition, subject matter competencies are specified in such a way that they cover aspects of the cognitive domain. Students should be able to develop and apply mathematical skills and abilities, use mathematical operations and problem-solving strategies, and apply mathematical knowledge and conceptual understanding to solve any mathematical or real life problem. Exhibit 1 presents a summary of the mathematics competencies that students should achieve in Grades 4–6.

Exhibit 1: Expected Mathematics Competencies, Grades 4–6

Content Area	Competencies
Numbers and Operations (up to 6 digits)	Understand place value, ways of representing numbers, and the relationships between numbers; understand fractions, recognize fractions as parts of whole units or parts of a collection, and represent fractions on the number line; understand decimal place value and represent decimals using words and numbers; understand the meaning of the four basic arithmetic operations and how they relate to one another; Compare and order whole numbers, simple fractions, and decimals; Use numbers and operations to solve problems, including those set in a real life context; Compute with numbers; and Estimate numbers, including estimations, while using the four arithmetic operations.
Algebra	Identify number patterns and the relationship between patterns (numbers or terms); Extend patterns; Generate patterns; and Write simple algebraic expressions to solve for one unknown and represent real life situations using models, symbols, pictures, and words.
Geometry	Identify and draw points, lines, rays, and line segments; Identify and describe quadrilaterals; Distinguish between parallel and perpendicular lines; Differentiate between two- and three-dimensional shapes; and Determine line of symmetry in two-dimensional shapes.
Measurement	Measure and estimate length, area, volume, mass, capacity, time, and circumference using metric system units.
Data Analysis	Collect, organize, represent, and display data in graphs, charts, and tables, including reading and interpreting data; and Calculate the mode and median from a set of data.

The mathematics curriculum content domain for Grades 7–9 covers the same five content areas as Grades 4–6 (Numbers and Operations, Algebra, Geometry, Measurement, and Data Analysis), but as learning progressions. That is, each content area is taught in more depth and has more difficult content than in earlier grades. Each content area contains defined topic areas, and the specified subject matter competencies cover aspects of both the content and cognitive domains, as for Grades 4–6. Exhibit 2 presents a summary of the mathematics competencies that students should achieve in Grades 7–9.

Exhibit 2: Expected Mathematics Competencies, Grades 7–9

Content Area	Competencies
Numbers and Operations	Understand numbers, fractions, decimals, ratio, and proportion and be able to carry out operations with them when solving problems; understand factors and multiples and solve problems using them; understand integers and rational numbers and compare, order, compute, and represent them; and understand operations using integers and rational numbers; Evaluate power of numbers and square roots; Simplify numerical expressions using the appropriate operation; Compare and order fractions, decimals, and ratios to solve problems; and Compute fractions and decimals and use this computation when solving problems.
Algebra	Extend and generalize well-defined patterns, finding the missing terms and use relations and functions; Explore properties of linear functions from tables, equations, and graphs; Demonstrate understanding of linear relationships and the concept of variables in solving linear equations and range of functions; and Model real life situations using multiple representations.
Geometry	Identify relationships between two- and three-dimensional shapes and use their properties in solving problems; Recognize different types of angles and use the relationships of angles with lines and in geometric shapes; Represent properties of geometric figures using a Cartesian plane to locate points and lines; Describe and draw a variety of geometric figures including angles, lines, triangles, and quadrilaterals; Use geometric transformations to recognize the properties of symmetry, similarity, and congruency in solving problems; and Use geometric models to represent numerical and algebraic relations.
Measurement	Recognize metric and customary units and demonstrate an understanding of relationships between units; Identify the suitable unit to measure angles, lines, circumferences, areas, and volumes; and Compute and estimate area, circumference, and volume.
Data Analysis	Read and represent data displayed in different forms (e.g., line plots, tables, and bar graphs); Describe and compare different representations of the same data; Calculate the mode, median, and range from a set of data; and Determine and estimate the chances of an outcome and use the chances of a particular outcome to solve problems.

Science Curriculum in Primary and Lower Secondary Grades

Similar to mathematics, second cycle (Grades 4–6) science competencies are specified to cover both cognitive and content domains, the latter of which comprises three content areas: Life Science, Physical Science, and Earth Science.[11]

Each of these content areas contains well-defined topic areas. Exhibit 3 presents a summary of the science competencies that students should achieve in Grades 4–6.

Exhibit 3: Expected Science Competencies, Grades 4–6

Content Area	Competencies
Life Science	Understand diversity and adaptations of living organisms by classifying them into major groups, such as mammals, insects, birds, and plants;
	Recognize the physical and behavioral characteristics of major groups of living things;
	Describe differences between living and nonliving things, identify the structures and functions of living things, including common characteristics such as reproduction, heredity, growth, and the need for water and air;
	Determine the relationship between major structures of animals and their functions;
	Identify and recognize the life cycle of familiar plants and animals;
	Understand how plant and animal reproduction produces offspring with features resembling the parents, and differentiate between the way animals and plants reproduce;
	Specify and describe the relationship between plants and animals in natural ecosystems;
	Understand basic knowledge related to human life and the surrounding environment, and identify the effects of the environment on physical features of plants and animals;
	Explain the effect of a simple food chain on any given community;
	Understand the effects of the environment on human behavior; and
	Define common diseases, such as colds and the way they are transmitted, explain ways of treating and preventing illness, and describe a healthy lifestyle.
Physical Science	Identify the three states of matter and understand the physical state of matter and its change from solid to liquid, and liquid to gas; and explain ways that matter changes from one form to another, and describe these changes;
	Understand mixtures and solutions;
	Determine physical properties of an object, such as weight, volume, and mass, and compare objects according to their physical properties;
	Define energy sources and explain how this energy is used;
	Describe how hot objects can affect cold objects, determine the heat conductor, and give an example of materials that conduct heat;
	Understand sources of light, electrical systems, objects that conduct electricity, and properties of magnets; and
	Describe all types of forces that cause objects to move and the effect of the object's weight on its motion.
Earth Science	Acquire information about the Earth, space, sun, moon, and solar system and the natural phenomena related to them, such as night and day and the seasons of the year; and
	Represent and use conceptual knowledge about air pressure, weather, and meteorology.

The translated McGraw Hill curriculum for the third cycle (Grades 7–9) has a content domain which comprises three content areas: Earth Science, Life and Environmental Science, and Physical Science. Each of these content areas contains well-defined topic areas and the science competencies, again, cover both content and cognitive domains. Exhibit 4 presents a summary of the science competencies that students should achieve in Grades 7–9.

Exhibit 4: Expected Science Competencies, Grades 7–9

Content Area	Competencies
Earth Science	Know and understand the Earth's physical characteristics;
	Describe the processes occurring on Earth, the use of Earth's natural resources, and methods of preserving these resources;
	Identify Earth's location in the solar system;
	Recognize the relationship between science, technology, and society and understand the effect of science and technology on the environment and society;
	Observe natural objects from different points of view and be able to define them;
	Acquire the necessary skills to be efficient in communicating with others;
	Use appropriate tools and procedures to measure and classify natural objects accurately; and
	Implement scientific experiments and activities using available materials from the environment and the laboratory and make judgments on issues or events by linking observations and relationships.
Life and Environmental Science	Describe cell types, structure, and functions; understand the relationship between the structure and function of an organism; and identify human organs, their functions, and how to protect them; and
	Understand reproduction, genetics, natural processes, and the effects of the external environment on the internal functions of living organisms.
Physical Science (Chemistry and Physics)	Define substances as a collection of tiny particles (molecules), which are in turn comprised of smaller particles (atoms);
	Classify substances into elements, compounds, or mixtures according to their characteristics;
	Differentiate between types of solutions, acids, bases, and salts, their properties, and use, and understand the changes a substance can undergo and the cause of these changes;
	Describe the physical state of a substance and how changes in state are related to the distance between the molecules of the substance;
	Identify forms of energy and how heat transfer occurs when a substance changes state;
	Understand the nature and characteristics of sound and how to distinguish different types of sound;
	Characterize the behavior of light and the result of its interaction with objects; and
	Understand electromagnetism, the dual relationship between forces and particles, and the types of forces and related theories.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

The school year in Bahrain lasts 32 weeks, beginning the first week of September and ending in June of the following year. At all educational stages, the school year is divided into two 16-week semesters, with an additional two weeks for breaks.[12] Daily total instructional time is six hours, with each class period lasting 45 minutes. Mathematics instruction is five periods per week in all three education cycles (Grades 1–9), while science instruction is three periods per week for the first two cycles (Grades 1–6), and four per week for the third cycle (Grades 7–9).

Instructional Materials, Equipment, and Laboratories

The revised curriculum is presented in translated mathematics and science textbooks, each divided into two parts—one for each semester. The ministry provides all public school students with textbooks, and all schools with accompanying teacher's guides and student exercise books. Textbooks are predominantly produced locally and compiled and printed by MoE, except for the translated mathematics and science textbooks, which are printed in Saudi Arabia at the expense of MoE.

Public schools have all the facilities needed for teaching and learning. For example, in 2010, all schools were outfitted with science laboratories and learning resource centers. MoE also provides private schools with textbooks free of charge for the subjects of Islam, Arabic, Bahrain history, Bahrain geography, and citizenship.

Use of Technology

Since 2001, computer use has been a school subject in basic education, and information and communication technologies (ICT) have been used to teach multiple school subjects. In 2005, King Hamad launched the Schools of the Future Project to stimulate ICT adoption in teaching and learning.[13] All schools in Bahrain have been equipped with electronic classrooms, utilizing a multi-purpose electronic learning system and connecting all schools electronically. By 2010, 100 percent of schools' learning resource centers had electronic classrooms equipped with multimedia devices to enhance presentation. Also by 2010, 100 percent of teachers had been trained to use computers and were prepared for International Computer Driving License qualification.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

In the first cycle of primary education (Grades 1–3), there is a single classroom teacher for most subjects. These teachers must have a bachelor's degree in education. For the second and third cycles (Grades 4–9), mathematics and science teachers are subject specialists who must have a bachelor's degree in their respective subject, along with a postgraduate diploma in education.

Homework Policies

The current (new) mathematics and science textbooks are accompanied by a teacher's guide and student exercise book. The exercise book provides different types of exercises, which measure students' level of thinking and skills. The teacher assigns exercises according to each student's level (i.e., above average, average, or below average), as specified in the teacher's guide. The teacher uses the exercise book to monitor students' abilities and progress in solving problems at home with parental guidance.

Teachers and Teacher Education

Teacher Education Specific to Mathematics and Science

Mathematics teachers in Bahrain must have a Bachelor of Science (BSc) in mathematics, and science teachers must have a BSc in any area of science. To be qualified as a specialist mathematics or science teacher, prospective teachers must complete a one-year postgraduate diploma in education in addition to the BSc, and then attend a MoE teacher program workshop in mathematics or science before starting to teach. Since 2008, mathematics and science specialists in the Directorate of Curricula have conducted approximately 13 workshops per year, trained senior mathematics and science teachers in all schools, and cooperated with the mathematics and science supervisors. These specialists also have trained all teachers in basic education one year before implementing the current (new) textbooks: Grades 1–3 in 2008, Grades 4 and 7 in 2009, Grades 5 and 8 in 2010, and Grades 6 and 9 in 2011.

Requirements for Ongoing Professional Development

MoE cooperates with the Economic Development Board in conducting a diagnostic test for senior mathematics teachers, supervisors, and curriculum specialists.[14] This test aims to establish a strategic mathematics plan that will enhance mathematics instruction and improve student performance. In general, this collaboration has found that Bahraini students were not proficient in the mathematics they study, and that they lacked the skills required to deal with numbers and mathematical operations. As a result, a national numeracy strategy was initiated and the Ministry of Education established its own Numeracy Committee. Currently, this committee is studying 51 mathematics units across Grades 1–6, prepared for Bahrain by an expert from the United Kingdom. The members of the committee are working on checking the units' translation and adaptation, in addition to training teachers so that the units for Grade 1 can be implemented by September 2012.

Monitoring Student Progress in Mathematics and Science

In 2007, the Evaluation and Assessment Center within MoE introduced a new school evaluation system in all schools in Bahrain in order to accurately monitor student progress in all subjects.[15] The evaluation system assesses student performance as follows:

- Daily class work, homework, and classroom quizzes in addition to teacher observations of student behavior, attitude toward classmates, and subject knowledge—30 percent;
- Midterm examination—20 percent;
- Project work, which varies across subjects (project work can be carried out by an individual or in a group)—20 percent; and
- End of term examination—30 percent.

As legislated in Article 4 of the Royal Decree, the Quality Assurance Authority for Education and Training is mandated to review the quality of the performance of education.[16] Within the Quality Assurance Authority, the National Examination Unit is responsible for evaluating student learning progress at Grades 3, 6, and 9 in the four major subjects—mathematics, science, Arabic, and English. The unit conducts examinations in these four subjects and collects information about the student, the school, and school performance. In May 2009, the National Examination Unit implemented examinations in all schools at Grade 3 (Arabic and mathematics) and Grade 6 (Arabic, mathematics, English, and science). In 2010, the examination was implemented at Grade 3 (Arabic and mathematics), Grade 6 (Arabic, mathematics, English, and science) and Grade 9 (Arabic, mathematics, English, and science), again for all public schools. The results of these examinations clearly match TIMSS results, although the national examinations measure the national curriculum criteria, which differ from the TIMSS assessment frameworks.

Impact and Use of TIMSS

The Kingdom of Bahrain's TIMSS 2007 national report identified significant indicators of weakness in teaching and learning mathematics and science in the country.[17] Bahrain's results in mathematics and science were not meeting international standards, and, in particular, mathematics results were far below the international average. The report was shared with educators and policymakers in order to produce new policies and methods to address low student performance and improve mathematics and science instruction.

The overall impetus to reform education in Bahrain arose from a number of factors: the evaluation of TIMSS results; the Economic Development Board's assessment of Bahrain's education in 2005; the need to achieve goals legislated in Education Law number 27 of 2005; and the requirement to fulfill ministry responsibilities as legislated by Article 5 in the Education Law.[18] All of these factors indicated the importance of quality teaching and learning; thus, improving the teaching and learning process was seen as necessary to enhance Bahrain's education.

Bahrain's TIMSS 2011 results will be used as indicators that will monitor the ministry's strategic goals for 2011–14. To meet these goals, MoE has implemented two initiatives: one to monitor student performance in public schools, and another to review and implement the new curriculum.

The first initiative focuses on regular monitoring of system progress as well as evaluating student achievement in relation to education standards. In order to improve Bahraini student performance, particularly in mathematics and science, TIMSS results in both subjects are being compared with international criteria. Consequently, Bahrain's participation in TIMSS will continue, and participation in PIRLS and PISA also have been highly recommended.

The second initiative focuses on curriculum review and revision to help students acquire necessary skills, such as problem solving, teamwork, and critical thinking. The analysis of Bahrain's TIMSS data also have shown the need to assess the mathematics and science curricula and implement improvements to encourage student achievement in these two subjects in each cycle of education. To enhance teaching and achieve these outcomes, students need a curriculum that promotes integration between all subjects as well as supplementary educational programs and school support, and some of these suggested actions arose directly from analyses of TIMSS results. Over three years (2011–14), this initiative will execute the following strategic plan:

- Introduce a curriculum centered on educational outcomes, which satisfies the integration of all subjects, reinforces values and citizenship, and stresses a balance between content and cognitive domains;
- Create cultural programs to reinforce values and citizenship;
- Prepare an item bank in each subject in order to train students to improve their achievement in national and international studies and competitions; and
- Employ programs to help students who are continuing on to tertiary education.

In 2009, the Arab Bureau for Education in the Gulf States (ABEGS) initiated a supervisory committee for international studies (TIMSS, PIRLS, and PISA). This committee meets frequently and comprises all ABEGS member countries (Bahrain, Kuwait, United Arab Emirates, Qatar, Saudi Arabia, and Yemen) as well as representatives from the emirates of Abu Dhabi and Dubai. The purpose of the committee is to support ABEGS countries' participation in international studies, assist with tools for using study results, and encourage participation among fellow countries.

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Belgium, Flemish Community[a]

TIMSS 2011

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Introduction

Overview of the Education System

Belgium is a federated country with three official languages: Dutch, French, and German. Flanders (the Flemish Region) is a Dutch-speaking community with six million inhabitants in the northern part of Belgium, although within Flanders, Brussels has French and Dutch as official languages. Wallonia is a French-speaking community within Belgium and there is also a German-speaking community in the Eastern part of Belgium.

A single Flemish Parliament and a single Flemish Government govern the Flemish Region and the Dutch-speaking Community, including the Dutch-speaking population of the Brussels-Capital Region. The Flemish Region is responsible for territorial issues such as economy, infrastructure, agriculture, the environment, and employment. The Flemish Community is responsible for citizen-related issues, namely providing services closely related to the language in which they should be carried out—education, welfare, public health, and culture.[1]

The Minister of Education heads the Flemish Ministry's Department of Education, and the Flemish Government supervises education policy from preprimary through university education. Although education is a community matter, federal Belgian authorities still retain some responsibilities, such as determining the start and the end of compulsory education, minimum conditions for obtaining a diploma, and pensions for education staff.

Quality control and quality promotion in Flemish Community education rely on three pillars:

- Attainment targets, which provide a clear frame of reference regarding quality embedded in society;

a A portion of this chapter's content is drawn from De Bent, J. (2007). Belgium, Flemish system. In A.M. Kennedy, I.V.S. Mullis, M.O. Martin, & K.L. Trong (Eds.), *PIRLS 2006 encyclopedia: A guide to reading education in the forty PIRLS 2006 countries.* Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College.

- The Inspectorate, which acts as a professional system of external supervision; and
- The Educational Guidance, a group of advisors overseeing the professional internal support of schools and centers. These advisors work within one of the educational networks.

The federal government defines criteria for monitoring the quality of curricula of each organizing authority, and must approve curricula and ensure that they contain attainment targets and minimum objectives. The government, via the Inspectorate, evaluates whether schools are making sufficient efforts toward meeting these attainment targets. In addition, the government examines whether the curriculum-based objectives are being reached and whether the developmental objectives and cross-curricular attainment targets have been sufficiently pursued.

Governing bodies (i.e., school boards) are key to the organization of education in Flanders, and can be responsible for one or several schools. These bodies are free to choose teaching methods based on a certain philosophy or educational view. They also can determine their own curriculum and timetables and appoint their own staff.

Most schools in Flanders are part of an educational network—an organization that supports a number of schools logistically, administratively, and pedagogically (e.g., the network of Catholic schools or public schools organized by a local council). In many cases, educational networks assume the responsibilities of the governing bodies—they draft their own curricula and schedules, taking into account the government's developmental objectives and attainment targets.

The Belgian Constitution guarantees that all children have the right to an education.[2] Education is compulsory and starts on September 1st of the year in which a child reaches the age of six. In principle, there are twelve years of compulsory schooling. A student must attend full-time compulsory education until the age of 15 or 16. After that, only part-time compulsory education is required (i.e., a combination of part-time study and work), although most young people continue to attend full-time secondary education. Compulsory education ends in June of the calendar year in which the student reaches the age of 18.

All children who reside in Belgium are required to attend compulsory education, including children of a foreign nationality. However, compulsory education does not necessarily require compulsory attendance in schools—home schooling also is possible. Also, children who are unable to attend school, primarily due to serious disabilities, may be exempted from compulsory education (including home schooling).

Access to education is free of charge through the end of compulsory education and primary and secondary schools that are funded or subsidized by the government cannot demand any fees from students. Similarly, access to Flemish Community nursery education (preprimary school) is free of charge, although it is not compulsory.

Freedom of education also is a constitutional right. Every natural or legal citizen has the right to organize education and establish institutions for this purpose, parents have the right to choose a school for their child, and authorities are not allowed to prohibit the establishment of private schools. In addition, authorities are constitutionally obliged to provide equal access to neutral education; each child is guaranteed that a public school supporting his or her (or his or her parents') religious or philosophical beliefs will be reachable by public transportation.

In Flanders, nursery and primary education are offered in two forms: mainstream and special. Mainstream nursery education is not compulsory and is available for children from ages two and a half to six years. Mainstream primary education is aimed at children six to twelve years of age (6 consecutive years of study), the start of which normally coincides with the start of compulsory education. Repeating a grade, especially the last grade of preprimary education or the first grade of primary education, is not uncommon; consequently, in the second grade, more than 10 percent of the children are older than the normal age. Special nursery and primary education are aimed at children who need special help, temporarily or permanently. Integrated nursery and primary education is the result of cooperative initiatives between mainstream nursery and primary education and special education.

Almost all children in Flanders receive nursery education. In mainstream nurseries, the teacher often is assisted by a qualified childcare worker. The main goal of nursery education is to stimulate the child's personality and to develop cognitive, emotional, and social skills in preparation for primary school. Nursery education is multifaceted; children learn such skills as language acquisition, motor development, and social skills, as well as an initial way of exploring the world, which can be built upon in primary education. Wherever possible, an attempt is made to connect the various learning areas. While preprimary schools have no official curriculum, they do have a nursery school work plan and developmental objectives, which are achieved through play. Many school governing boards have developed instructional methods and curricula to meet attainment targets, formulated by decree, for five learning areas: physical education, musical education, Dutch, introduction to the world (e.g., nature, people, society, technology, time, and space), and introduction to mathematics.

The five learning areas for primary school are nearly identical to those for preprimary school. The only differences are that, in primary school, French is added to the language learning area and attainment targets are formulated for two additional areas: learning to learn and social skills. However, in Flemish Community primary education, it also is possible to organize education thematically instead of around learning areas.

The Primary Education Certificate is awarded to students after evaluation at the school level. Students can obtain this certificate at the end of the sixth year of primary school or at the end of the first year of secondary education (Grade 7). Students who need additional assistance because of poor performance are admitted to an alternative track in secondary school that provides this support and can earn a certificate equivalent to the Primary Education Certificate.

In 2006, 84 percent of Flemish Community young adults (ages 25–34) had at least a certificate of secondary education, which is higher than the Organization for Economic Co-operation and Development (OECD) average (77%). Nevertheless, many young people finish compulsory education without a certificate or diploma, and attempts are being made to change this trend by means of a modularization project, which allows students attending vocational schools the opportunity to complete their education in a well-defined module (i.e., specialization area).[3]

Languages of Instruction

The official language in Flanders is Dutch. Similarly, the only language of instruction in the Flemish Community and in the Dutch-speaking schools in the region of Brussels is Dutch. In Brussels and in the region that borders Brussels or the Walloon provinces, many children from French-speaking homes attend Dutch-speaking primary schools.

The percentage of pupils with a home language different from Dutch varies from city to city. The larger cities in Flanders tend to have significant immigrant populations and several mother tongues are spoken in the home. In the classroom, these children are educated in Dutch.

Mathematics Curriculum in Primary Grades

In primary schools, mathematics education includes a number of important areas of emphasis, and mathematics instruction is designed to help students achieve the following: [4]

- Acquire the basic mathematical knowledge, insight, and skills (with respect to symbols, terms, concepts, and procedures) which are necessary to function properly in society, and which constitute an essential foundation for future study;
- Apply acquired mathematical knowledge, insights, and skills to meaningful and real situations, as well as to other areas of learning;
- Understand the language of mathematics;
- Develop an orientation towards investigation, which can help detect and investigate mathematical relationships, patterns, and structures;
- Use appropriate search strategies to solve mathematical problems;
- Learn to direct mathematical reasoning and learning processes and to reflect on them;
- Display a constructively critical attitude towards mathematics, in general; and
- Develop a positive attitude towards mathematics as a discipline.

Exhibit 1 presents the mathematics domains and objectives to be accomplished in the mathematics curriculum throughout primary education (Grades 1–6).

Exhibit 1: Domains and Objectives in the Mathematics Curriculum in Primary School[5]

Domains	Objectives
Numbers (and Operations)	Knowledge of the concept of quantity, and of the various ways of expressing quantities with numbers (e.g., whole numbers, decimal numbers, and fractions); Mental and written arithmetic operations (i.e., addition, subtraction, multiplication, and division); and Estimating and computing ratios and percentages, and using a calculator.
Measurement	Measuring physical objects, including various skills for use outside the classroom; Measuring physical variables (e.g., distance, mass, time, and temperature), and using a scale; Reading and using units of measurement to accurately measure geometric variables (e.g., perimeter and surface area); Working with units of measurement; and Estimating a measurement result.
Geometry	Understanding concepts related to orientation and location in two-dimensional space; Recognizing and naming shapes; Reasoning from geometric properties; Finding connections between shape and size (e.g., similarity and congruence); and Making simple geometric constructions.
Strategies and Problem Solving Skills	Recognizing the process- and problem-oriented nature of mathematics; and Applying acquired insights and concepts (e.g., the practical value of mathematics and problem solving).
Attitudes	Thinking critically about numbers and reflecting on the problem solving process.

Science Curriculum in Primary Grades

In Flanders, different disciplines (biology; physics; history and geography; and psychology, philosophy, and sociology) provide an overall structure within which students systematically acquire scientific concepts, patterns, skills, and attitudes. In the primary grades, science is taught as the subject World Orientation. This subject has six domains, or spheres of reality—nature, technology, man, society, time, and space—each with its own developmental objectives and attainment targets. This goal of science education at this level is for students to accomplish the following:

- Develop basic competencies that allow them to explore themselves and their environment in an increasingly profound way;

- Become interested in the lives of people, present and past, at home and abroad;
- Develop a basic attitude of openness and respect towards nature, man, and society; and
- Develop the basic skills to manage information independently.

In the primary grades, the Flemish Community curriculum describes the content of World Orientation as well as the objectives for the topics of animate and inanimate nature, health and environmental education, and technology. Specifically, students acquire knowledge, understanding, skills, and attitudes about animate nature (e.g., people, animals, and plants as biological creatures) and inanimate nature (e.g., weather and climate, the universe, and materials); objectives concerning health and environmental education are linked to this content.[6]

Instruction for Mathematics and Science in Primary Grades

Most schools use a mathematics textbook series that has been developed by an educational publishing house and has usually been tested in practice. These textbooks are generally written by teachers or educational counselors. The majority of schools choose one particular series of textbooks that is then used throughout the school (i.e., in all classrooms) to ensure continuity.

In the primary grades, Flemish Community students explore mathematics in the real world. First, they count and classify tangible materials. Next, they use pictorial and other visual representations (the perceptive level) before, finally, moving on to mental or abstract mathematics.

A Flemish Community mathematics class generally begins with a short review exercise and the formulation of a problem. The next phase involves group instruction by the teacher, following which students work under supervision. Students then do exercises independently from a workbook before the lesson concludes with feedback and a brief evaluation. During some classes, group instruction is immediately followed by individual work for strong and intermediate students, while the teacher provides more instruction to weaker students.

For science teaching, approximately three in four schools use a series of textbooks developed and designed thematically by educational publishing houses. The remaining schools do not use textbooks; rather, they use lesson materials they have composed themselves, usually involving topics that cover all domains of science.

In the textbooks, a lesson starts with a description of an observation of reality and with the formulation of a problem. This is followed by an investigation, in which students try to account for reality by comparing, ordering, and classifying. Due to the use of textbooks, contact with nature and concrete experiences tends to be de-emphasized as the starting point of science. Thus, too often, knowledge is emphasized over skills.

Instructional Materials, Equipment, and Laboratories

Generally, Flemish Community schools are adequately resourced with sufficient materials to reach the attainment targets.

Many mathematics tools are available in the primary grades, including building materials, strings of beads, materials from the Man and Biosphere program, abacuses, multiplication tables, number lines, hourglasses, chronometers, analogue and digital clocks, scales, thermometers, calendars, fraction tables, measuring and drawing materials (e.g., protractors, compasses, triangles, and rulers), geometric figures, floor plans and maps, and calculators.

The following science-oriented materials are present in most schools: anemometers, barometers, visual aids (e.g., photographs, slides, and videos), first-aid kits and Band-Aid boxes, hygrometers, identity cards for plants and animals, compasses, lists of endangered species, scale-models (replicas), environmental books, observation logs, pictograms involving weather observations, rain gauges, scale models, thermometers, magnifying glasses, compass roses, weather vanes, representations of the solar system, and sketches or other didactic materials.

Some schools, usually in rural areas or suburbs, have a school garden or a children's farm.

Use of Technology

Information and communications technology (ICT) skills are becoming increasingly important for both children and adults, and ICT is influencing teaching and learning methods. New cross-curricular attainment targets and developmental objectives for ICT have been in use in nursery and primary education and in the first stage of secondary education since September 1, 2007.[7] In order to achieve these attainment targets, the Flemish Government designed a five-pillar policy that aims at the following:

- Strengthening the policy-making power of schools at the institution level;
- Improving the expertise of education staff;
- Providing a high quality infrastructure;
- Designing an appropriate policy on teaching resources; and
- Encouraging research and ICT monitoring.

The goal of this policy is to encourage schools to integrate ICT into classroom practice through information and awareness-raising campaigns, in-service training, infrastructure development, and project funding. While these ICT initiatives are not aimed specifically at mathematics or science, schools are urged to use ICT in ways that are appropriate for individual subject areas. For example, students may use the Internet to search for information to help their comprehension or use software that provides remedial instruction.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Individual classroom teachers in primary schools instruct students all year in the following areas: language, mathematics, world orientation (science), and art education. In addition, primary schools have a number of particular tutors in the subjects of physical education, art education, and religion (philosophical subjects), for example.

Homework Policies

Homework policies are determined at the school level. Schools are free to decide whether to assign homework and school regulations state how much homework can be assigned. The amount of homework is usually negotiated with the parents. On average, Flemish Community primary schools assign mathematics homework twice per week for a maximum of 40 minutes per week. Teachers assign less science homework, which mainly consists of looking up information or carrying out an investigation (e.g., plant growth or weather observation). Once a year, students also might prepare a presentation on an animal or a plant.

Teachers and Teacher Education

Teacher effectiveness and assessment have been emphasized greatly in recent policy declarations. The goal of one such decree was the integration of all types of teaching courses into one coherent framework and the implementation of important changes in the area of in-service professional development.[8] In the decree, minimum requirements were incorporated in the form of teacher profiles developed by the Department for Educational Development. These profiles contain common competencies for all teachers regarding knowledge, skills, and attitudes, as well as specific competencies connected with a specified level of education (i.e., preprimary, primary, or secondary). The attitudes incorporated into the profile have a bearing on all types of functions; they affect decision-making, the ability to form relationships, eagerness to learn, the ability to organize, the desire for teamwork, sense of responsibility, creativity, flexibility, and the ability to use language appropriately and correctly.

Initial teacher education includes a three-year course for teachers of preprimary, primary, or (the first phases of) secondary school, in which there is a distinction between teacher education courses and their academic (i.e., subject area) courses. In addition, continuing education courses allow teachers to acquire the necessary qualifications for a particular aspect of the teacher's profile.

There is no official teacher education specific to teaching mathematics or sciences; it is part of the general education of the primary school classroom teacher. Some private organizations, led by volunteers and professionals, have developed initiatives to support teacher education related to specific mathematic issues. These often involve lectures, conferences, and symposia.

Requirements for Ongoing Professional Development

In-service professional development plays an important role in giving teachers the opportunity to work toward developing a professional profile during their careers.

The aforementioned decree regarding teacher education and in-service professional development introduced a completely new system of further training initiatives.[9] The decree states that the organizing authority of the school in which the teacher works is responsible for supporting all teachers in their quest for further professionalism. This professional development may contribute towards the management of the complex interactions between teaching staff and students, teachers with one another, students among themselves, or teachers and the outside world. The teachers also receive systematic in-service education and guidance to help them improve their assessment methods (e.g., developing and using teaching materials and sample tests).

Supporting teachers new to the teaching profession also is of great importance to the future development of their careers, and schools pay particular attention to the initial supervision of beginning teachers.

Monitoring Student Progress in Mathematics and Science

The Department for Educational Development in Flanders treats quality control and monitoring subject matter very differently than most other countries.[10]

In the Flemish Community, education is explicitly regarded as more than training and instruction. In addition to educational material, a school also must convey values, attitudes, and convictions according to its (freely specified) pedagogical framework. These often lead to outcomes that do not easily lend themselves to exact measurement in the community. For this reason, there are no externally imposed tests and no national examinations. The schools themselves decide whether the students have attained all of the objectives (attainment targets and their own objectives) and, thus, use their own tests and award qualifications themselves.

In preprimary education, there is no formal assessment. However, at this level, observation-based assessment is used and has the following three purposes:

- Forward-looking—Is the degree of maturity and development attained by the child sufficient for continuation in primary school?
- Gauging—What has the child learned and how advanced is the child in comparison with his or her peer group?
- Diagnostic—Why has the development of a child been delayed, or why has knowledge not been acquired in particular areas?

The transition from preprimary to primary school, a stage which can be problematic, places greater demands on the Student Guidance Center, together with the school's educational team. The Student Guidance Center (CLB) is a center funded by the government that students, parents, teachers, and school management teams can consult for information, assistance, or guidance regarding issues of education, health care, or psychological and social functioning. The CLB is free of charge and monitors the welfare of students.

In primary education, teachers are encouraged to employ an approach emphasizing success and positive encouragement, taking into account the difficulties inherent in the proposed objectives and the varying abilities of the students. At this level, teachers conduct tests each year to assess student achievement of stated objectives and to evaluate teaching efficacy. All examinations and testing are recorded by teachers, under supervision of school management. The results of examinations, usually taken in December and June, are used together with other classroom assessments administered throughout the school year to formulate student grades. At regular intervals, a school report informs each student and his or her parents of the student's achievement results, progress, attitude toward learning, and personal development.[11] Based on a student's results, parents can decide to have their child repeat a grade or attend special education.

Most Flemish Community schools use a set of educational materials for mathematics, including tests (linked to the method used) which check whether students sufficiently master instruction. In addition, a follow-up system is applied independently from the method used to verify student achievement level or learning gain.

For science, schools either use tests linked to the curriculum, if the curriculum has been obtained through an educational publisher, or schools make tests themselves.

Any admission to special education requires an enrollment report providing evidence that special education is necessary. When parents are advised to send their child to special education, they are not compelled to do so; it is their decision. Parents of children with learning difficulties in mathematics decide if their child will attend mainstream primary school or special education, with advice from the CLB or another recognized service and the school. If a school asks the CLB to supervise a student, the center always will ask for parent consent. Supervision provided by the CLB is multi-disciplinary and focuses particularly on students with learning difficulties relative to their social background and situation.

Many students with special needs are able to remain in regular education with some special attention and aid from a teacher or remedial teacher. In many cases, students may repeat a grade. However, regular education is unable to meet the needs of some students who need special assistance temporarily or permanently. Special education schools provide these children with adapted education, training, care, and treatment. Approximately 7 percent of children in Flemish Commuity elementary education attend special education due to a physical or mental handicap, serious behavioral or emotional problems, or severe learning disabilities.

Impact and Use of TIMSS

Flanders participated in TIMSS between 1995 and 2003; however, because results were rather good, TIMSS did not have a large impact within the community. If future achievement results, either generally or for a specific subgroup, show a decline, then Flemish interest in TIMSS would likely increase.

Perhaps the most important impact of TIMSS to date has been that people from other regions and countries know that the educational system in Flanders is rather effective.

Suggested Readings

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Botswana

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Introduction

Overview of the Education System

At the primary level, Botswana's education system is the joint responsibility of two ministries—the Ministry of Education and Skills Development (MoESD) and the Ministry of Local Government. The Ministry of Local Government is responsible for the infrastructure of primary schools, administering nine main local authorities called districts, which are subdivided into 28 sub-districts. MoESD oversees curriculum and staffing at all levels of schooling and solely administers secondary and tertiary education. This joint system is meant to decentralize services and provide effective supervision.

The government is the main source of educational funding, which has steadily increased over the past few years. According to the 2007–08 national budget, MoESD was allocated 28 percent of the ministerial recurrent budget and 8 percent of the development budget, while in 2011–12 the ministry was allocated 31 percent of national budget—the largest single share.[1]

Botswana has a national curriculum administered by the Department of Curriculum Development and Evaluation (CDE) within MoESD. Curriculum goals are derived from the ministry's education policy. Department officers are responsible for forming committees and task forces comprised of teachers, education officers, university and college lecturers, and other stakeholders to develop teaching syllabuses for each subject in the curriculum and to prescribe the books used to teach these syllabuses for each subject.[2]

Preprimary education in the country has traditionally been provided by private individuals and organizations registered with MoESD. Most offer both social and academic elements, though frequently without a standardized or set curriculum. However, the government has established a unit of preprimary education within the Department of Primary Education, with the intention of linking preprimary education to formal schooling. Recommendation 9(c) of the Revised National Policy on Education of 1994 states that a "preprimary 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 program and supervising preprimary education." [3]

Botswana provides a ten-year basic education which is not statutorily compulsory, as no parent is taken to task for not sending their children to school. Grades (standards) 1–10 form the basic education cycle. The structure of the education system includes seven years of primary education, followed by three years of junior secondary education and, finally, two years of senior secondary education. The seven years of primary education consist of four years lower primary and three years upper primary. At the end of the seventh year students write the Primary School Leaving Examination in the following subjects: English, Setswana, Mathematics, Social Studies, Science, Agriculture and Moral Education. This is a diagnostic examination and not consequential, thus students proceed to junior secondary even with lower grades. At the end of the three-year junior secondary level the students write the Junior Certificate Examination for purposes of selection to senior secondary school. Senior secondary education marks the end of pre-tertiary education with a consequential examination. Entry age is officially six years, though some children may start late due to various factors, such as the type of settlement in which they reside.

Most schools in Botswana are government owned and run. Only about 8 percent of schools are private, compared to approximately 13 percent of secondary schools.[4] As of 2005, parents contribute only 5 percent of the total expenditure for the secondary education of their children, while primary education remains free for citizens.

Private schools are owned and run by individuals or organizations, but all are registered with MoESD. Fees paid by parents are the main source of funding in these schools. Most private primary schools design their own curricula, which are more advanced than the one offered in government schools. Students in private schools take the Primary School Leaving Examination. Private secondary schools mostly offer an 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 absent from school for unknown reasons.[5] Although the 1977 National Policy on Education has done well to expand the provision of education, quality of education and low achievement remain challenges within the system. The Revised National Policy on Education acknowledges the current state of Botswana's educational system:

> As a result of the adoption of the National Policy on Education in 1977, educational development has been characterized 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]

Emphasis on Mathematics and Science

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

> 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.[8]

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

Languages of Instruction

Setswana is the national language and English is the official language in Botswana, though other languages are spoken. English is the medium of instruction in government schools beginning at Grade 2 through the tertiary level, while instruction in English begins in pre-school in private English-medium schools. Although students are only taught in Setswana in first grade, Setswana is taught as a compulsory subject for citizens of Botswana throughout the primary and secondary school system

Mathematics Curriculum in Primary and Lower Secondary Grades

The mathematics syllabus at primary school is divided into a lower primary syllabus (Grades 1–4) and an upper primary syllabus (Grades 5–7). At Grade 4, students take national achievement tests in three subjects, including mathematics.[9]

The lower primary school mathematics syllabus (Grades 1–4) is organized around modules, divided into topics, and then subdivided into general and specific objectives. The specific objectives outline the breadth and depth of teaching required in a particular topic. Five modules are covered by the lower primary syllabus: Numbers and Operations, Geometry, Measures, Problem Solving, and Statistics.

- Numbers and Operations—This module prepares students to understand the concept and use of numbers. Students are exposed to counting, sorting, and classification of numbers, as well as matching objects and numbers. These concepts lead to addition and subtraction. By the end of Grade 4, students should be able to add and subtract three-digit numbers vertically and horizontally. They should also be able to multiply using one- to three-digit numbers and do simple division. Students should also understand money, local currency denominations, and units as well as be able to add, subtract, multiply, and divide using money.
- Geometry—Shapes and solids are used to introduce Geometry. Learners identify shapes such as rectangles and triangles, and solids such as cubes and cylinders. By the end of Grade 4, students should be able to describe shapes by number of sides and number of angles and be able to name solids.
- Measures—The intention of this module is to develop measuring skills. Students start by comparing lengths and weights at Grade 1 and gradually begin using standard measuring instruments. By the end of Grade 4, students should be able to use formulas to calculate areas and perimeters. In addition, they should be able to use instruments to measure volume and mass, and be able to convert units of length, units of time, and units of mass.

- Problem Solving—This module introduces learners to practical problem-solving skills. Skills are developed through mathematical games, simple puzzles, and simple investigations involving numbers and shapes. By Grade 4, students should be able to conduct simple research projects.

- Statistics—This module introduces simple methods of data collection and simple statistical presentations, such as pictographs. By the end of Grade 4, students should be able to interpret information and draw simple statistical conclusions, such as finding the mode.

The upper primary mathematics syllabus (Grades 5–7) is designed to help students develop further numeracy and computational skills as well as problem-solving skills. The same five modules covered by the lower primary grades continue to be emphasized in the upper primary syllabus:

- Numbers and Operations—The aim of this module is to teach students to read whole numbers up to 10,000 and write these numbers in words. By the end of upper primary, students should be able to do the following: apply the basic arithmetic operations (addition, subtraction, multiplication, and division) in the correct order when working with whole numbers, fractions, and decimals; and be able to use percentages to increase, decrease, and compare quantities.

- Geometry—In this module, students learn to name two- and three-dimensional geometric shapes and recognize their properties. Students do the following: differentiate straight lines from curves and use rulers, compasses, and squares to draw perpendicular and parallel lines, angles, and shapes; and work with Cartesian coordinates in the first quadrant and carry out simple transformations (translations, reflections, and enlargements).

- Measures—The curriculum is designed to help students appreciate measurements, use measuring devices, and estimate quantities. Students do the following: use instruments to measure length and determine the perimeter of regular and irregular shapes; and calculate area of shapes and volume of objects, and measure the volume of various objects using displacement methods.

- Algebra—Students are introduced to algebra as a method of communicating mathematics through symbols. Students do the following: generate number patterns and completing linear sequences; replace missing numbers in boxes, which later are represented by letters; and simplify linear expressions and translate simple statements into algebraic expressions and equations. By the end of Grade 7, students should be able to solve equations of the form $ax + by = c$ through systematic trial and error using whole numbers. In addition, they should be able to use substitution to evaluate simple expressions.

- Statistics—The aim of this module is for students to develop manipulative skills on collecting, organizing, and analyzing data, as well as understanding basic concepts of probability. Students are expected to do the following: read and interpret data; be able to collect and organize data by tabulation, and draw pictographs, charts, and other graphs; be able to find the mode and the median, and calculate the mean. By the end of upper primary, students should know the meaning of probability and be able to describe probability in terms such as "likely," "unlikely," "never," and "certain." In addition, they should have explored the likelihood that an event may occur through simple games and experiments.

When students complete Grade 7, they proceed to Grade 8 and begin studying toward the Junior Certificate of Education (JCE), which takes three years to complete. At the end of this curriculum, students should be able to apply computational skills for use in everyday life, both commercial and social.

The JCE, or lower secondary school mathematics syllabus (Grades 8–10), has the same organization as the primary school syllabus. Generally, lower secondary school extends primary school learning and students are expected to begin applying concepts to solve practical problems. Five topics are covered: Numbers and Operations, Geometry, Measures, Problem Solving, and Statistics.

- Numbers—Students do the following: apply arithmetic operations (addition, subtraction, multiplication, and division) to whole numbers, decimals, fractions, and directed numbers; solve problems involving percentages, money, and ratio and proportion; approximate and estimate using significant figures and round numbers to specified accuracies; square, cube, and find square and cube roots of real numbers, including fractions; derive laws of exponents by investigation and apply laws of integer exponents in problem solving; solve problems using numbers in scientific notation. In addition, students are expected to be able to do the following: understand simple money and non-money bank transactions; be able to calculate labor costs, material costs, and overhead costs of basic projects; understand and solve problems involving insurance policies, simple interest, contracts, income tax, and duty charges; and be able to add and subtract matrices and multiply a matrix by a scalar.

- Measures—Students do the following: investigate the relationship between the circumference of a circle, the related diameter, and π (pi);

calculate the length of arcs and the perimeter and area of composite shapes, as well as the volume of cubes, cuboids, and cylinders, including composite cross sections; work with problems that involve time, distance, and speed, and use and interpret distance-time graphs; and calculate speed in km/h, m/s, and other metric units.

- Algebra—Students should be able to do the following: simplify linear expressions and use substitution to solve equations for one variable; expand and factor binomial expressions of the form $(a \pm b)^2$, and factor expressions of the form $ax^3 \pm bx^2 \pm cx \pm d$; use graphical methods to solve simultaneous equations; and solve linear simultaneous equations in two unknowns by Gaussian elimination and by substitution.
- Geometry—Students do the following: construct geometrical elements, such as line segments, parallel lines, perpendicular lines, and angle and perpendicular bisectors; construct triangles and quadrilaterals; understand and use properties of angles to solve problems and calculate unknown angles using angle properties, such as corresponding angles, alternate angles, interior angles, and complementary and supplementary angles; describe line and rotational symmetries, and solve problems involving angle properties of triangles and quadrilaterals; plot points in all four quadrants of the Cartesian plane and join them to form shapes; and draw graphs of functions of the form $y = mx + c$ and $y = ax^2 + bx + c$.
- Statistics and Probability—Students do the following: collect, process, and tabulate grouped and ungrouped data; use grouped and ungrouped data to draw and interpret bar graphs, pie charts, and line graphs; calculate and interpret the mean, the median, and the mode of ungrouped data; and interpret scatterplots for given data or situations using the best fitting line; and interpret basic concepts of probability and distinguish theoretical probability from experimental probability, as well as calculate probabilities of single events for up to twelve outcomes.

Science Curriculum in Primary and Lower Secondary Grades

According to the national Environmental Science curriculum, students should be taught the following topics or skills by the end of Grade 4:[10]

- Our Surroundings—Living and non-living things (observe the surroundings; and compare living and non-living things); and care of the surroundings (demonstrate proper care of one's surroundings; and demonstrate proper methods of managing waste).

- The Non-living Environment—Sky, seasons, and weather (observe bodies in the sky; and observe and record weather conditions); natural resources (identify sources and uses of water; demonstrate proper methods of conserving water and soil; and investigate properties of rocks and soil).
- The Living Environment—Observing plants (observe features of plants); uses of plants; growing plants; and ourselves and other animals (acquire knowledge on different body parts and their functions; and investigate the importance of animals and their habitats).
- Health and Safety—Personal hygiene; safety; and food and nutrition (demonstrate proper methods of preparing, preserving and storing food; and demonstrate healthy eating habits).

According to the national Environmental Science curriculum, students should be taught the following topics or skills by the end of Grade 8:[11]

- Science and Society—The nature of science (recognize how scientific knowledge is developed and organized, and apply the scientific method to solve problems); history of science; and technology in science.
- Nature and the Universe—The environment; plants (importance of photosynthesis; cycle of flowering plants; and germination and seed dispersal); animals (classification and adaptation); air; water; weather; and the solar system.
- Matter and Energy—Matter; and energy (different forms of energy; properties of heat and light; and the nature and uses of sound).
- Force and Motion—Force; and levers and simple machines.
- Electricity and Magnetism—Static electricity; current; magnets; and electromagnetism.
- Health and Safety—Food and nutrition; diseases; safety; and alcohol and drug abuse.
- Body Systems—Human body systems (functions of digestive, circulatory, reproductive, skeletal, and nervous systems; and functions of major organs of the digestive system).
- Sexual Reproductive Health—Physical development; human reproductive system (reproduction in humans, and stages of pregnancy and problems of teenage pregnancy); sexually transmitted diseases; and HIV and AIDS.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Mathematics is taught each year of primary school. Government school policy indicates that students should be taught in mixed-ability groups for mathematics. At both the primary and junior secondary school levels, instructional time for mathematics is three hours, 30 minutes per week. The Department of Curriculum Development and Evaluation (CDE) determines these time allotments in the curriculum blueprint.

Instructional Materials, Equipment, and Laboratories

Instructional materials, including prescribed student textbooks, teacher's guides, and supplementary materials for each grade, are used to enrich and explain the curriculum. Textbooks developed by independent publishing companies are examined by a book review committee and then presented to CDE for evaluation. CDE recommends textbooks and provides primary schools with teacher's guides. Additionally, CDE has produced a booklet directing junior secondary school teachers in the development of instructional materials, including teaching and learning methodologies, guidance in gender sensitive content issues, and language use.

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

Use of Technology

The availability of computers is very limited in primary schools, the exception being private schools and English medium schools. Most junior secondary schools (Grades 8–10) have computers or computer laboratories, though not all schools are equipped with these resources. Nevertheless, all students at junior secondary school are mandated to take a basic computer course. In addition, Internet connectivity is very minimal, compounded by lack of electricity in some schools. Calculators are also introduced in Grade 8.

Both the Mathematics and Science syllabuses encourage the use of technology. Two of the aims of the three-year integrated science and mathematics programs are as follows:

1. Development of an awareness of computer applications in mathematics activities; [12] and

2. Acquisition of basic computer skills and an understanding of the significance of computers in the study of science and in science related careers.[13]

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Subject specialization currently is completed by teachers at the secondary level only.

Homework Policies

There is no national policy on homework. Policy development in this area occurs at the school level.

Teachers and Teacher Education

Teacher Education Specific to Mathematics and Science

Since 2000, teachers are required to complete a three-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. Formerly, the minimum qualification for primary school teachers was a two-year Primary Teachers Certificate. The last cohort of these teachers graduated in 1999. During their study at secondary colleges, prospective mathematics teachers spend about 58 percent of time on content and about 42 percent on pedagogy, while science teachers spend 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 complete a six-week course during which they practice teaching in schools under the supervision of experienced teachers. College lecturers also visit and make assessments, which eventually form part of the prospective teacher's final grade.

Before the late 1980s, Botswana's shortage of mathematics and science teachers was remedied by recruiting expatriates in secondary schools. This ended when secondary colleges of education started producing teachers to supplement those from the single local university, which had been the sole institution for training secondary school teachers.

Requirements for Ongoing Professional Development

The Department of Teacher Training and Development, within the Ministry of Education and Skills 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. As part of TIMSS 2003 and 2007 findings, the majority of teachers indicated that they do not participate in professional development activities, though they were not probed further to ascertain why.[14]

Monitoring Student Progress in Mathematics and Science

Throughout their formal schooling, students take various national examinations, which serve numerous purposes beyond enhancing the teaching and learning of the curriculum. One example is the Standard Four Attainment Test, administered at the end of Grade 4, which covers mathematics and the Setswana and English languages. The purpose of the test is to assess learning progress so that appropriate action (e.g., retaining or promoting a child to the next grade) can be taken. If students do not perform well on this assessment, parents consult with the schools about promotion. A second national examination—the Primary School Leaving Examination—is taken at the end of Grade 7 by students at both private and government schools. Historically, this examination was used for selecting those who would proceed to junior secondary education. However, this is no longer the case, because the ten years of basic education now extends to the end of junior secondary education. Thus, the assessment has become a diagnostic examination, informing schools, districts, and other stakeholders of students' strengths and weaknesses. At the end of Grade 10, students take the Junior Certificate Examination, used for selecting those who will proceed to senior secondary school. Some of those who do not qualify for senior secondary may take the vocational education path, while others may enter into employment. 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.

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 and receive reports and discuss their child's progress with teachers. Remedial programs are offered under school supervision.

Apart from retention at Grade 4, described previously, the country practices automatic promotion from Grades 1–4, Grades 5–10, and Grades 11–12. However, the Revised National Policy on Education calls for a change of this policy, recommending instead "a policy of assessed progression." [15]

Impact and Use of TIMSS

Botswana has participated in TIMSS 2003 and TIMSS 2007.[16] Achievement by Botswana's Grade 8 students for these two TIMSS cycles was not satisfactory, with a mean performance both in Math and Science of about 350 points, and with about 68 percent of Grade 8 students failing to reach the Low International Benchmark. The 2007 TIMSS report was disseminated to the relevant stakeholders, such as the Ministry of Education and Skills Development Heads of Departments, School Heads, Regional Education Directors, parents, teachers, and representatives from other educational institutions. Dissemination teams held regional workshops in an effort to reach as many teachers as possible. Even though Grade 8 is the first year of lower secondary schooling, primary school teachers were invited to these workshops, because performance in Math and Science at this level is determined by the primary school classroom instruction.

Similar to the TIMSS 2003 reports, the TIMSS 2007 International Reports identified similar background variables as having a negative influence on achievement in Math and Science. These variables include, but are not limited to the following:

1. Pedagogical issues, such as availability of resources, teacher effectiveness, and student motivation and aspirations;

2. Curriculum issues, such as proficiency in English language, imbalances in performance by gender (girls performing significantly higher than boys), an imbalance in cognitive areas in the curriculum, and urban/rural disparities;

3. Social and environmental context, such as lack of parental involvement in the child's learning, teacher absenteeism, and access to pre-school; and

4. Teaching and learning resources, such as urban/rural disparities in resources provision, and lack of well-resourced libraries.

The recommendations from the TIMSS 2007 report to MoESD have not been consolidated into interventions by the ministry, but similar recommendations from the TIMSS 2003 report resulted in some interventions in the education system. There also has been some restructuring within MoESD, leaving the Department of Teacher In-Service almost non-existent. The TIMSS team may need to work closely with teachers, schools, regional heads, and In-Service to conduct workshops on how to teach reasoning, application and syntheses, and other process skills, because Botswana Grade 8 students are seriously challenged in these areas. There is a need for teachers to learn how to construct questions that require reasoning and the application of skills. The use of TIMSS released items for both Math and Science can be helpful in this initiative. At the moment, the items are sent to schools without any further follow-up on their use.

The CDE has already developed the primary and junior secondary syllabuses that will be in use by the next cycle of TIMSS.

Mathematics and Science Teaching Interventions

- SMASSE Program—As a result of the recommendation from Revised National Policy on Education of 1994 (RNPE 1994) and recommendations resulting from TIMSS 2003, the Ministry of Education and Skills Development implemented a program known as SMASSE (Strengthening of Mathematics and Science in Secondary Education). Started in 2006, the SMASSE program aims to strengthen and enhance the quality of performance, teaching, and learning of mathematics and science in secondary schools.[17] Originally adapted from Japan, the SMASSE program resulted from benchmarking with Kenya, which had introduced a similar program due to poor achievement in mathematics and science. The Kenyan study found that classroom teaching and learning practices were ineffective in mathematics and science due to factors such as teacher and student attitudes, teaching and learning resources, and facilities.[18] The model adopted for Botswana, called the Activity-focused Teaching/Learning, Student-centered Teaching/Learning, Experiments, and Improvisation (ASEI) movement, encompasses four basic principles that guide the SMASSE in-service teacher training activities: Plan, Do, See, and Improve (PDSI).

- Curriculum Review—In 2006–07, the Department of Curriculum Development and Evaluation within MoESD reviewed the upper primary (Grades 5–7) and junior secondary school (Grades 8–10) curricula. In addition to benchmarking with other countries and using the TIMSS mathematics and science frameworks, the poor achievement of Botswana students on TIMSS 2007 and the resultant recommendations influenced these two reviews. The reviews focused more on content than the delivery of the curriculum.

- Higher Order Thinking Skills (HOTS)—Findings from TIMSS showed that acquisition of cognitive skills in mathematics and science by students in Botswana was poor. Students were not able to apply higher order thinking skills, such as critical thinking and problem solving. The review of the curriculum for primary and secondary education put emphasis on the acquisition of these skills across all subject areas, including mathematics and science. The Botswana Examinations Council also enhanced assessment objectives to include HOTS and developed assessment instruments that would allow students to demonstrate critical and creative thinking, problem-solving, and performance skills. This intervention was introduced in 2008 to target the Primary School Leaving Examination and the Junior Certificate Examination, both of which assessed the revised curriculum.

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Chile

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Introduction[a]

Overview of the Education System

The Ministry of Education is the national office in Chile responsible for promoting the development of education at all levels and assuring that the population has access to primary and secondary education. The ministry proposes, evaluates, and oversees educational policies, plans, and their fulfillment. It sets general norms, assigns the necessary resources to develop educational activities, assesses educational development as an integral process, and informs the public about educational results.[1]

The Ministry of Education has decentralized authority into regional secretariats in each of the 15 administrative regions of the country. Each regional secretariat is responsible for supervising the development of the educational process in the educational centers located in their territory as well as overseeing the fulfillment of the educational policies and objectives, with consideration for regional needs and interests. Regions are sub-divided into provinces, of which there are 54 total in Chile. Provincial departments provide technical pedagogical assistance and supervision, and oversee administrative and financial inspection of nationally subsidized schools.

In 2010, there were 12,157 schools in Chile, serving 3,554,320 students.[2] Among these, there are schools that have a different relationship with the state concerning their administration and funding: municipal schools (comprising 47.1% of all schools and enrolling 40.4% of all students), private subsidized schools (47.3% of schools, enrolling 52.3% of students), and private paid schools (5.5% of schools, enrolling 7.2% of students).[3]

Municipal schools are administered by local governments (municipalities) but are funded by the national government, although municipalities and, in high school education (upper secondary education, Grades 9–12), parents also may provide some funding, the latter of which may not exceed a certain limit. Private subsidized schools are privately administered and funded by the

a The information in this chapter about the Chilean education system is based on 2010, because the TIMSS 2011 assessment was administered in Chile in November 2010. In 2011, the national education system and the national curriculum began a significant restructuring. For more information on this restructuring, please refer to Chile's Ministry of Education website: http://www.mineduc.cl national government. The administrator also may provide funding and parents may be required to contribute financially, but the fee may not exceed a certain limit. Private paid schools are privately administered, funded by parents, may receive funding from the administrator and do not receive any government funding. The Ministry of Education officially recognizes all of these educational institutions if they accomplish the Ministry's requirements, and parents can choose among them for their children's education.[4]

National funding for municipal and private subsidized schools is given directly to schools and consists of a fixed amount of money per student. This amount varies according to school level and the socioeconomic background of students attending the school. Additional funding for each enrolled student from a disadvantaged background is given on the condition that the school community submits an agreement with the Ministry of Education which requires the school to develop a learning and institutional management improvement plan and restrict selection of students (until the end of primary education) on the basis of prior or potential educational achievement.[5] Additional funds also are given to schools that are located in rural difficult access areas.[6]

The Ministry of Education does not have direct control over school governance. However, it does have influence through public policies. Technical pedagogical decisions typically are made by the school principal, the technical pedagogic coordinator, the board of teachers, or by consultations among all parties. All municipal and privately subsidized schools must have a school council consisting of representatives of parents, students, teachers, the school principal, and representatives of the administrator of the school. Schools that are not mandated to have this council must have a school committee in charge of promoting a peaceful and respectful coexistence among the school members. The school council's role is to be informed about school matters and discuss the school's educational proceedings, such as extracurricular activities, school goals, and disciplinary matters. School councils are not concerned with teaching matters or curricula.[7] The administrator of the school, who may be the municipality, a private corporation or foundation, among others, normally makes administrative decisions, sometimes in consultation with the school principal. Private schools have more autonomy than municipal schools. In privately administered schools, teachers are hired by the school administration, while in municipal schools they are hired by the municipalities. Some hiring conditions are determined by a state law that also standardizes base salaries.[8]

Chile's current school system comprises eight years of basic education (*educación básica*), which combines primary and lower secondary education (Grades 1–8), and four years of high school (*educación media*), which corresponds to upper secondary education (Grades 9–12). These twelve years of education are compulsory. Basic education starts when students are six years old.[b, 9] Exhibit 1 presents the structure of the compulsory levels of education and student enrollment rates in 2010.[10]

Exhibit 1: Compulsory Levels of Education and Student Enrollment Rates, 2010

Levels of Education	Grades	Student Ages	Gross Rate of Student Enrollment [c]	Net Rate of Student Enrollment [d]
Basic Education (primary and lower secondary education)	1–8	6–13	102.6%	95.1%
Upper Secondary Education	9–12	14–18	95.6%	79.8%

Preschool education is offered by preschool institutions as well as by some municipal and private schools, and includes five non-compulsory years. Most schools that offer Grade 1 also offer one year of preschool education. In 2010, 90 percent of children attended kindergarten (the last year of preschool).[11] However, overall preschool enrollment for younger children is low: 76 percent attended pre-kindergarten for ages 4 years to 4 years, 11 months.[12] Although preschool education is not compulsory, by law the government must encourage student enrollment as well as guarantee free access to pre-kindergarten and kindergarten financed by the national government.[13]

Schools offer primary and lower secondary education (basic education), upper secondary education (high school), or both (complete schooling). Some schools only offer Grades 7–12 and others, mainly very small rural schools, only offer Grades 1–4 or 1–6. Schools with upper secondary education offer humanistic-scientific education, technical professional education (vocational), or both. These tracks start with differentiated curricula at Grade 11. Some schools offer specific artistic education. For students with special educational needs in some regular and in special educational schools, human and technical resources as well as specific knowledge and assistance attend to these needs, whether temporary or permanent.[14]

The Ministry of Education is responsible for developing the national curriculum, which determines the mandatory fundamental objectives and

b This school structure was changed in the General Education Law of 2009: basic education will comprise Grades 1–6 and high school will comprise Grades 7 –12. This change will be implemented in schools 8 years after the official adoption of the law in 2009.

c Gross enrollment rate includes students of any age.

d Net enrollment rate includes only students at the age that corresponds to the levels of education shown.

minimum content to be taught in each grade and subject in all schools. The national curriculum must be approved by the National Educational Council, which is independent from the ministry. However, schools are free to decide how to implement the curriculum and may include additional educational objectives, content, and programs. In primary and lower secondary education (basic education), there is one common curriculum for mathematics and science because students at this level all follow the same track. In upper secondary education, there is one common curriculum for Grades 9 and 10, but different curricula for Grades 11 and 12, depending on whether students follow the humanistic-scientific or technical professional tracks.[15]

Based on the curriculum, the ministry develops study plans, which specify the minimum number of instructional hours that should be devoted to each subject. The ministry also provides study programs to guide teaching. These study plans and study programs must be approved by the National Educational Council. Teachers are not required to use these study programs, though the ministry recommends them as an orientation for teaching.[e, 16]

Languages of Instruction

The vast majority of the population in Chile speak Spanish. Some ethnic languages also are spoken, including Mapudungún (spoken by the Mapuche people from the south of the country), Aimara (spoken by the Aimara people from the Northern Andes), and Rapa Nui (spoken by people from Easter Island).[17] The language of instruction for mathematics and science is Spanish in the vast majority of schools, but there also are a few bilingual schools where these subjects are taught in a foreign language. In schools with a high number of indigenous students, the school must offer a program to teach students their ethnic language, although enrollment in the program is optional.[18]

Mathematics Curriculum in Primary and Lower Secondary Grades[f]

The 2010 primary and lower secondary (basic education) mathematics curriculum dates from 1996 but was updated in 2002. In 2009, there was another update for Grades 5–8.[19, 20] Exhibit 2 summarizes the fundamental mathematics objectives for Grades 3–4, and Exhibit 3 summarizes the fundamental objectives for Grade 8.

e For more information on the national curriculum, study plans, and study programs, please refer to the national curriculum website: http://www.curriculumnacional.cl

f In 2012, the national curriculum began a significant restructuring. Therefore, the following description corresponds to the curriculum that was current for students in 2010.

Exhibit 2: Mathematics Curriculum Fundamental Objectives, Grades 3–4

Content Axis	Fundamental Objectives
Numbers	Interpret data using numbers up to six digits in different situations, and use numbers to communicate information orally and in writing; Interpret and organize numeric information in tables and bar graphs; Comprehend the meaning of quantities expressed by numbers up to six digits by rounding, estimating, and comparing quantities and measurements; Recognize that a number is contained in its multiples; Understand the decimal number system; and Use fractions to understand and communicate information.
Arithmetic Operations	Apply addition and subtraction to more complex situations than in the previous level and extend calculation procedures to numbers of more than three digits, consolidate mental calculation strategies, and develop summarized procedures of written calculation; Identify multiplication and division as operations that can be used to model relationships and allow the determination of unknown information from available information; Make mental calculations of products and quotients, using a memorized repertoire of basic multiplicative combinations, strategies linked to the character of the decimal number system, and properties of multiplication and division and the relationship between them; Make written calculations of products and quotients and remainders using procedures based on the additive decomposition of numbers, properties of multiplication and division and the relationship between them, and proper symbolism associated with these operations; Estimate results of arithmetic operations; Use a calculator to determine sums, differences, products, and quotients, when required by the complexity of the calculations; Make statements about properties of multiplication and division from patterns observed in calculating many examples of products and quotients; and Compare arithmetic operations in terms of their meaning and the properties used in the calculations.
Shapes and Space	Characterize and compare polygons with three and four sides, using geometric language that incorporates the intuitive notions of angles and parallel and perpendicular sides; and draw polygons according to given features; Recognize what remains constant in two-dimensional shapes submitted to transformations that keep their shape, size, or both features; Label, characterize, and compare straight prisms, pyramids, cylinders, and cones; designate their elements, such as faces, edges, and vertices; and construct solids according to given features; Identify and represent geometric objects and bodies in one plane; and Interpret and produce graphical representations of trajectories.

Content Axis	Fundamental Objectives
Problem Solving[g]	Manage basic aspects of problem solving, such as data analysis, exploring alternative solutions, and anticipation, interpretation, communication, and evaluation of results; Solve problems concerning the following: construction and use of numbers; concepts of multiplication and division, their possible representations, and calculation procedures and applications; use of the four arithmetic operations in equations; analyze, map, and transform plane figures, and two-dimensional representations of geometric solids; and use drawings and plans to communicate locations and trajectories; Solve problems appropriate to the grade level to deepen and expand knowledge of the natural environment, and of social and cultural development; and Solve mathematics problems that include numbers, arithmetic operations, and geometry.

Exhibit 3: Mathematics Curriculum Fundamental Objectives, Grade 8

Content Axis	Fundamental Objectives
Numbers	Multiply and divide whole numbers; and Use calculation strategies that involve the use of exponentials with whole-number bases and natural-number exponents, determine and apply their properties, and extend them to exponentials with fractional or positive decimal bases and natural exponents.
Algebra	Recognize functions in different contexts, identify their elements, and model relationships with them; and Identify variables in direct proportion and in indirect proportion, and solve problems in various contexts that involve the use of proportional relationships.
Geometry	Characterize and make isometric transformations of flat geometric figures, recognize some of their properties, and identify situations in different contexts that correspond to applications of those transformations; and Understand circumference and circle as geometrical concepts; and use the concepts of perimeter, area of a circle, surface of a cone, and volume of a cylinder to solve problems in different contexts.
Data and Chance	Interpret information from frequency tables, where data is grouped in intervals, and use this type of representation to organize data from various sources; Interpret and produce information in different contexts using measures of central tendency, extending the case of data grouped into intervals; Understand the concept of randomness in the use of samples and its importance in making inferences; use measures of central tendency to analyze the characteristics of a sample of data; and explain the information these measures provide; and Theoretically determine probabilities of events in random experiments with finite and equally probable results, and compare them with experimental results.
Problem Solving[h]	Use simple forms of mathematical modeling, verify simple propositions for particular cases and apply basic problem solving skills in different and meaningful contexts, assess the validity of the obtained results, and use these to inform opinions and make decisions.

g Problem solving is conceived in the curriculum as a cross-cutting ability that is taught and developed through all preceding content axes.

h Problem solving is conceived in the curriculum as a cross-cutting ability that is taught and developed through all preceding content axes.

Science Curriculum in Primary and Lower Secondary Grades[i]

The 2010 primary and lower secondary (basic education) science curriculum dates from 1996 but was updated in 2002. In 2009, it was again updated for Grades 5–8.[21, 22]

The science curriculum for Grades 1–4 is included in a subject titled Natural, Social, and Cultural Comprehension of the Environment, which includes social science and integrated natural science. Exhibit 4 summarizes the fundamental science objectives for Grades 3–4. In Grades 5–8, an independent subject titled Comprehension of the Natural World corresponds to integrated natural science. Exhibit 5 summarizes the fundamental science objectives for Grade 8.

Exhibit 4: Science Curriculum Fundamental Objectives, Grades 3–4[j]

Content Axis	Fundamental Objectives
Structure and Function of Living Things	Understand the processes of growth and reproduction of plants, animals, and humans, and recognize similarities and differences among these groups of organisms; and Apply basic principles of the classification of living things.
Organisms, Environment, and Their Interactions	Understand relationships between living things and their environment in terms of basic requirements of life and adaptation processes.
Matter and Its Transformations	Recognize changes in states of matter and appreciate the importance these processes have for everyday life; and Apply basic principles regarding physical objects.
Earth and Universe	Know and apply different representations of the Earth and recognize Earth's place in the solar system and our galaxy.

Exhibit 5: Science Curriculum Fundamental Objectives, Grade 8

Content Axis	Fundamental Objectives
Structure and Function of Living Things	Understand that the cell is a unit common to the organization, structure, and function of unicellular and multicellular life forms, and that the cell is a carrier of genetic information; Explain the processes of collection and disposal of nutrients at the cellular level and their relation to the integrated operation of organ systems; and Understand the core principles of a balanced diet in relation to people's nutritional requirements, according to their energy needs.
Organisms, Environment, and Their Interactions	Understand the main theories and facts that support and refute the origin of life and their impact on the scientific community and society; and Describe the progressive emergence of increasingly complex life forms over evolutionary time.

i In 2012, the national curriculum began a significant restructuring. Therefore, the following description corresponds to the curriculum that was current for students in 2010.

j Although scientific thinking skills are not explicitly presented as fundamental objectives in the primary curriculum, some skills are expressed in the introduction to the curriculum for these grades as cross-cutting abilities that are taught throughout each content axis.

Content Axis	Fundamental Objectives
Matter and Its Transformations	Understand the use of atomic models and the atomic theory to explain the processes of physical-chemical transformations of matter, and understand the use kinetic theory to explain phenomena related to the behavior of gases and liquids; and Explain, based on atomic models, the basic phenomena of static electricity, electrical and heat conduction, and the emission and absorption of light.
Force and Motion	Describe the effects of electric forces in phenomena at atomic and molecular levels.
Earth and Universe	Recognize the existence of different types of rocks, the processes involved in their formation, and the relationship of these processes to fossil structures; and Recognize different transformations experienced by the Earth throughout geologic time, and describe large-scale natural phenomena and their consequences for life.
Scientific Thinking Skills[k]	Formulate a hypothesis in relation to a simple research problem and recognize that an untestable hypothesis is not scientific; Design and conduct an investigation to verify a hypothesis and develop a written summary of the procedure followed; Formulate problems and explore different alternatives to find appropriate solutions and make decisions; and Understand that accumulated scientific knowledge is provisional and subject to change based on new evidence.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

The Ministry of Education developed a study plan prescribing the minimum mandatory time allocated to each subject in instructional hours (45 minute units). Mathematics is taught for six instructional hours per week in Grades 1–4 and five instructional hours in Grades 5–8. Science is taught for five instructional hours per week in Grades 1–2, six hours in Grades 3–4, and four hours in Grades 5–8. The hours allocated for Grades 1–4 are for Natural, Social, and Cultural Comprehension of the Environment, which includes both social and integrated natural sciences. [23, 24, 25]

Instructional Materials, Equipment, and Laboratories

In addition to the per-student funding provided to subsidized schools, the ministry provides other materials to support teaching and learning. The ministry solicits bids for the development of textbooks for core subjects, including mathematics and science, and selects the most appropriate textbooks in terms of the quality of content, activities, and guidance for teachers. These textbooks are distributed free of charge to all subsidized schools at the beginning of each school year and also are available at the Ministry of Education's school textbooks website.[26] As stated above, the ministry provides schools with study programs to guide teaching.

k Scientific thinking skills are conceived in the curriculum as cross-cutting abilities that are taught and developed throughout all preceding content axes.

Through its Learning Resources Center, the Ministry of Education also provides a collection of learning resources to subsidized schools upon request. This collection includes books, electronic digital materials, periodic publications, and additional materials that aim to help teachers in curriculum implementation. The ministry provides education to the school team overseeing the library of materials acquired from the Learning Resources Center.[l] By 2009, the center had implemented 8,255 libraries across the country.[27]

Use of Technology

The Ministry of Education has a Center of Education and Technology (*Enlaces*), which has promoted information and communication technologies (ICT) as an important issue in education. In accordance with its mandate, the center has provided computers, Internet access, and educational software to schools and has educated teachers on the use of ICT. It also provides digital learning resources through its website. On average, there are 27.3 computers per school (10.5 students per computer), more than 65 percent of schools have Internet access (57% of them have broadband), and over 1,500 schools have received educational softwareAs of 2011, over 22,000 teachers had been trained to use ICT.[m, 28]

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Beginning at Grade 9, students are taught by specialist teachers for mathematics and science. In some schools, specialist teachers begin teaching students at Grade 7 or 8.

Homework Policies

Chile has no formal policy regulating homework.

Teachers and Teacher Education

Teacher Education Specific to Mathematics and Science

A professional certification is mandatory for qualification as a basic education teacher, although the certification need not be an academic degree. There are different routes to obtain certification—via universities, professional institutes, and special programs within these institutions. Programs of study include both pedagogical and academic subject instruction and generally last between four and five years, with each institution determining the duration of its program. High school (upper secondary school) teachers may obtain their professional

l For more information on the Learning Resources Center, please refer to http://www.bibliotecas-cra.cl/index.htm

m For more information on the Ministry Center of Education and Tecnology, please refer to http://www.enlaces.cl certification through combined teacher education programs in which they take disciplinary and pedagogical courses. Some institutions also offer a program for students that already have completed undergraduate studies in areas such as mathematics, science, and language. These programs last between one and two years and, following completion, students obtain a teacher professional certification that enables them to teach in upper secondary school. Many institutions also require students to attend training periods at schools and a professional practicum supervised by the school that lasts between three and six months.[n] There also are special programs for persons with prior experience in teaching but who do not have formal education or who have not completed programs of study for preparation as regular teachers. They can become officially qualified by engaging in teacher education programs that offer intensive courses delivered over relatively short time periods.[29]

The basic education teacher certification enables teachers to teach different subjects, including mathematics and science, from Grades 1–8. Upper secondary (Grades 9–12) teachers are subject specialists, and these teachers may only teach the subjects in which they are specialized.

In 2009, the Ministry of Education implemented a new diagnostic voluntary assessment program (*Inicia*) for students that have finished their studies to become teachers. Its immediate goal is to provide universities with feedback on how well they are educating future teachers, but its ultimate purpose is to enhance the overall quality of the teaching profession in Chile.[30]

Requirements for Ongoing Professional Development

In-service teachers from municipal schools are evaluated by a mandatory formative National Evaluation System for Teachers, *Docente Más*, which is administrated by the Center for the Improvement, Experimentation and Pedagogical Investigation from the Ministry of Education and aims to strengthen the teaching profession and improve the quality of education. The evaluation consists of self, peer, and supervisor assessments together with a portfolio assessment (including written and audiovisual material). The results of this evaluation are provided to the assessed teachers, the school principal and management team, and the school administrator (in most cases, the education director in the municipality, and are delivered with different levels of aggregation, depending on whom the results address. Since the evaluation system was launched in 2003, over 70,000 teachers have taken this assessment.[31]

n In 2011, the Ministry of Education launched a scholarship for all students that have finished secondary education and are interested in becoming a teacher. In order to obtain this scholarship, students must obtain a certain result on the National University Selection Examination and apply to institutions and teacher educational programs that have been certified by the National Accreditation Council. The scholarship finances the registration an anual fees. For more information on this scholarship, please refer to Chile's Ministry of Education website: http://www.mineduc.cl

Teachers who obtain positive results in the evaluation also may take a written test of disciplinary and pedagogical knowledge. Those who obtain positive results receive an additional yearly allowance for a certain amount of time.[32]

The Ministry of Education also initiated a Teaching Excellence Allowance (*Asignación de Excelencia Pedagógica*) to improve the quality of education by recognizing the professional excellence of teachers from municipal and private subsidized schools. To apply, teachers take a voluntary assessment consisting of a portfolio and a pedagogical and disciplinary test. Depending on teachers' results, they receive a bonus for a certain amount of time.[33] Moreover, distinguished teachers can apply to form part of the Expert Teachers Network (*Red Maestros de Maestros*). The network, also launched by the Ministry of Education, aims to improve teachers' professional careers by leveraging distinguished teachers' capabilities to contribute to the professional development of teachers as a whole.[34]

Monitoring Student Progress in Mathematics and Science

In Chile, students are individually assessed in every subject by their teachers. Grade promotion depends on academic progress. Primary and lower secondary education (basic education) and high school (upper secondary education) school diplomas are given by schools. In officially recognized schools, no national tests are used to determine grade promotion or to obtain a diploma. However, in non-officially recognized schools, in order to obtain promotion students must approve a special national test by the end of basic education and by the end of upper secondary education.[35] The Ministry of Education administers a national assessment (called SIMCE) to assess student learning outcomes at the school and national level.[o] SIMCE is conducted in all schools every year in Grade 4 and every other year in Grades 8 and 10. In Grades 4 and 8, students are assessed in the areas of reading, mathematics, integrated natural science, and social science; in Grade 10, students are assessed in reading and mathematics.[p] For Grades 4 and 8, results are expressed as scale scores and also as achievement levels (all areas in Grade 4 and reading and mathematics in Grade 8) describing what students are able to do at different cut points on the assessment's scale. Results are made public at the school, regional, and national levels, but do not have consequences for individual students. After each evaluation, the Ministry of Education sends reports to school principals,

o In 2013, the national assessment will be conducted within the Quality Education Agency, a recently created institution that is independent from the ministry. For more information on this new institution, please refer to Chile's Ministry of Education website: http://www.mineduc.cl

p Since 2010, other national assessments have been incorporated. For more information on these new assessments, please refer to Chile's Ministry of Education website: http://www.mineduc.cl teachers, and parents. These reports describe school-level results and trends, and also provide contextual information collected through various sources, including questionnaires administered to students, teachers, school principals, and parents.[q, 36]

Impact and Use of TIMSS

Before TIMSS 2011, Chile participated in TIMSS 1999 and TIMSS 2003.

At the beginning of the 1990s, Chile implemented a curricular reform. Since then, the primary and secondary education curriculum has been updated several times. Since 2000, updates have taken into consideration the approaches of international studies.

It became evident from TIMSS 1999 that the mathematics and science curriculum was misaligned with what was considered necessary to learn and assess from an international perspective. In addition, despite certain improvements in the reform curriculum implemented in Grade 8 as of 2002, an analysis of TIMSS 2003 showed there were still important differences between the TIMSS frameworks and the revised curriculum, especially in algebra and geometry and in physics and environmental science. The 2009 changes to the mathematics and science curriculum took into consideration some of the contents and approaches outlined in TIMSS 2003.[37]

In 2003, the Ministry of Education, through the Curriculum and Assessment Unit, initiated a process aimed at creating progress maps (content standards) for preprimary, primary, and secondary education. These progress maps were designed to visually display learning progress in different areas of the national curriculum and to describe the development of the key competencies fostered by the curriculum from Grades 1–12. TIMSS and other international studies were used as reference in developing these progress maps.[38]

Soon after creating the progress maps, the afore-mentioned achievement levels were developed, beginning with Grade 4 and following with Grade 8. These were established with the aim of providing teachers, schools, and parents with descriptive information on what students knew and were able to do in the subjects assessed by SIMCE. In this endeavor, TIMSS international benchmarks were used as a guide for formulating achievement levels for particular content areas.[39]

Chile's participation in international studies also has led to important improvements in many areas of assessment and evaluation. The use of Item Response Theory (IRT) advanced quickly in Chile following the country's

q For more information on the national assessment of student´s learning outcomes, please refer to SIMCE´s website: http://simce.cl participation in TIMSS 1999. Similarly, TIMSS has provided valuable knowledge on item construction and development of open-ended response items and scoring guides. Using TIMSS 2003 as a reference, SIMCE also has improved contextual background questionnaires, which now are based on a widely reviewed and discussed framework.[40]

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Chinese Taipei

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Introduction

Overview of the Education System

The administration of education in Taiwan is a three-tiered system that includes the Ministry of Education (MoE) at the central level, regional departments of education at the provincial level, and local bureaus of education at the county or city level. The functions and authority of these governmental organizations are different. Before the 1990s, the central government set educational policy at the local level. Since then, however, educational reforms have led to an increase in the authority of local governments over educational policy.[1, 2]

Formal education from the preprimary through the university level includes nine years of compulsory education. The total time that a student spends in formal education varies but normally includes two years of preprimary school, six years of primary school, three years of junior high school, three years of senior high school or senior vocational school, and two to seven years of junior college, college, or university. The compulsory education program, implemented in 1968, comprises Grades 1–9 (primary school and junior high school). Currently, the Ministry of Education is preparing to implement a twelve-year compulsory education program in 2014.[3] After college or university, advanced education programs toward either a master's degree (one to four years) or a doctoral degree (two to seven years) are optional. At all levels of formal education, special education programs are available to students with physical or mental disabilities.

Since the 1990s, the public has called for educational reforms in response to societal changes. Beginning with the Education Basic Law, which was announced on June 23, 1999, many reform initiatives have been carried out.[4] Among them, the implementation of the Integrated Curricula for Grades 1–9 and the Multi-route Promotion Program have exerted the greatest influence on primary and secondary school educational practices.[5]

Before these educational reforms, primary and junior high school curricula were developed separately by independent committees and were not integrated. To eliminate the discrepancies between these curricula, education officials invited experts in education and subject-related areas to create an integrated curriculum framework for Grades 1–9. Based on this framework, the Grades 1–9 curriculum guidelines were implemented for first grade in 2001 and for all grades in 2004.

In Taiwan, as in other Asian countries such as Japan, Korea, and Singapore, an academic degree is extraordinarily valued. To meet student interest, encourage motivation to learn, and reduce pressure on both students and their parents, the Multi-route Promotion Program for Entering Senior High Schools was announced in 1998 and implemented for all junior high students in 2001. The details of this program are discussed at the end of this chapter (see Monitoring Student Progress in Mathematics and Science).

On December 20–21, 2002, the Ministry of Education and the National Science Council convened the First National Congress on Science Education, whose committee members consisted of experts in mathematics and science education. Based on their consensus, the ministry published the *White Paper on Science Education*.[6] The *White Paper* is a blueprint to improve science education and related policies, and outlines the following short-term goals for science education:

- Coordinating related units of government in properly distributing budgets and implementing policies;
- Prioritizing the goals of science education on the basis of the demands of education, social change, and globalization;
- Enhancing the relevance of teaching methods in science education and their correspondence to science education goals; and
- Evaluating the implementation of science education in order to substantiate policy review and modification.

The long-term goals of science education include the following:

- Legislating regulations for organizations, personnel, procedures, and budgets for science education policies;
- Modifying and proposing guidelines for science education through academic research and evaluation; and

- Cultivating experts in science education policy and science education administration.

In addition, the *White Paper* suggests giving priority to the following:

- Establishing criteria for excellence in science education in order to evaluate the accountability of government units for promoting science education;
- Organizing the Teaching Material Center to conduct research and meet the goals, content, and spirit of the national science curriculum standards;
- Inviting researchers in science education and special education to investigate the learning characteristics of students with low science achievement or those with physical and mental disabilities;
- Funding the budgets of the National Science Council and the Ministry of Education for promoting popular science education;
- Enhancing cooperation between the National Science Council and the Ministry of Education in order to sponsor the integration of related research on science education practice;
- Establishing research centers of science education to promote high-quality research on science education; and
- Establishing a national committee for evaluating science teacher development.

Languages of Instruction

The population of Taiwan is 23 million. Most inhabitants are descendants of immigrants from mainland China, particularly those from the southeastern coastal provinces of Fujian and Guangdong. Taiwan also has 0.5 million indigenous people from 14 different tribes: the Amis, the Atayal, the Bunun, the Kavalan, the Paiwan, the Puyuma, the Rukai, the Saisiyat, the Sakizaya, the Sediq, the Thao, the Truku, the Tsou, and the Yami.[7]

The official language of Taiwan is Mandarin Chinese, but many people also speak Min-nan (the Southern Min dialect). Smaller groups of Hakka and indigenous people still preserve their own languages, and some elders speak Japanese, if they had been taught to use it when Taipei was colonized by Japan before 1945.

In primary and secondary schools, Mandarin Chinese is the language of instruction for most subjects, including mathematics and science. Schools also offer courses in Taiwanese dialects and foreign languages. Beginning in third grade, students are required to study English.

Mathematics Curriculum in Primary and Lower Secondary Grades

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 are the following:

- Develop the ability to work with algorithms, use abstract reasoning, make inferences, and communicate their understanding;
- Develop problem solving skills;
- Learn the foundational mathematics necessary for advanced mathematics; and
- Develop an appreciation for the beauty of mathematics.

The curriculum guidelines specify five mathematics strands, according to the grade level: Number and Quantity, Geometry, Algebra, Statistics and Probability, and Mathematical Connections. Indicators of competence, based on student cognitive development and the relationships within a strand and across strands in Grades 1–9, are provided within the curriculum guidelines.[8] The objectives of the five strands are briefly outlined as follows:

- Number and Quantity—In primary school, students are expected to master arithmetic operations (addition, subtraction, multiplication, and division) with natural numbers; understand the concepts of time, distance, area, weight, volume, capacity, angles, and the units used 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. The junior high school curriculum includes arithmetic operations on integers and rational numbers, prime and composite numbers, and arithmetic and geometric sequences.
- Geometry—In Grades 1–3, students learn to identify, explore, and manipulate geometric figures. In Grades 4–5, students are expected to express numerical relationships in and among geometric figures. In Grades 6–7, spatial and visual reasoning are developed. In Grades 8–9,

plane geometry is studied as an introduction to the concept of mathematical proof and appreciated for its intrinsic value.

- Algebra—Students learn to solve problems using symbolic representations. In primary school, students learn to express relationships in equations or in sentences, evaluate algebraic expressions, and solve simple linear equations. In junior high school, students learn to do the following: use equations or inequalities to represent the relationships between quantities described in questions, solve linear equations and inequalities in one variable and simultaneous linear equations in two variables, factor polynomials, solve quadratic equations, and represent linear and quadratic functions in graphs.
- Statistics and Probability—This strand has strong connections to algebra as well as to number and quantity. Students are introduced to the concept of probability, interpretation of data, and problem solving with statistics. In primary school, students mastering this academic content will be able to create and interpret simple statistical tables and pie charts. In junior high school, students learn about frequency, mean, median, and mode, and how to use computers to make tables and graphs.
- Mathematical Connections—To encourage meaningful learning, this strand emphasizes integration among the other four strands and the transfer of mathematical knowledge and reasoning from school to daily life, as well as to other subjects, such as science and technology.

Science Curriculum in Primary and Lower Secondary Grades

The goal of the science curriculum is to increase science literacy. Science literacy encompasses eight domains: knowledge of science and technology, science processing skills, development of processing intelligence, scientific applications, designing and producing, understanding the nature of science, understanding the development of science and technology, and development of scientific attitudes. The science and technology curriculum 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). Competence indicators for each of the four stages are listed separately in the Grade 1–9 Science and Technology Curriculum Guidelines.[9] The objectives of science learning in the eight domains are as follows:

- Knowledge of science and technology—Five themes comprise this domain: composition of nature and its features, actions of nature, evolution, life and environment, and sustainable development. Each theme has several topics (e.g., in actions of nature there are three topics: changes and equilibrium, structure and function, and interaction). Each topic consists of several subtopics (e.g., structure and function contains the structures and functions of plants and animals).
- Science processing skills—Science processing skills are the executive skills related to conducting scientific inquiry. In addition to problem definition and evaluation (described in the processing intelligence domain), science processing skills include observation (recognizing meaningful variables and measuring them quantitatively), comparison and classification (defining and controlling variables), organization and connection (using evidence to establish causal relationships), induction and inference (explaining data), and communication (acquiring information, developing clear and scientific statements, and expressing oneself appropriately).
- Development of processing intelligence—Processing intelligence refers to the scientific thinking used to define, develop, and evaluate problems. It comprises comprehensive thinking (forming integrated points of view from evidence), inferential thinking (making predictions based on scientific rules and theories), creative thinking (finding solutions from different perspectives, facing challenges flexibly, and acting with reflection), critical thinking (comparing reality to ideal or theoretical conditions and reasoning about the comparison), and problem solving (planning and evaluating solution methods and strategies).
- Scientific applications—Scientific applications refer to the use of the scientific method and knowledge learned in the classroom to solve daily-life problems. This domain emphasizes the transfer of problems and living strategies from school to daily life.
- Designing and producing—Designing refers to identifying people's needs and conceiving a way to satisfy those needs. Producing means using technical and practical knowledge to choose appropriate tools and materials to create products that satisfy an identified need.
- Understanding the nature of science—This domain refers to the properties of scientific knowledge and research activities. Students are expected to reflect on their science learning experiences, recognize the existence of natural laws, and master scientific argumentation.

Scientific argumentation requires students to differentiate evidence from theory, consider the internal consistency of explanations, and construct relationships between evidence 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 relationship between science and technology), the evolution and advancement of technology (knowing technology in agricultural, industrial, and information eras and trends of technology development), and technology and society (making sense of the ways technology interacts with our lives, the interaction between the development of industry and technology, etc.).
- Development of scientific attitudes—Scientific attitudes covers four learning stages: the joy of carrying out explorations (Stage 1, Grades 1–2), the joy of discovery (Stage 2, Grades 3–4), being careful and tangible (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

According to the *General Guidelines of Grades 1–9 Curriculum of Primary and Junior High School Education*, a school year consists of 200 school days, and students must attend school five days per week.[10] Each school day includes periods of subject-area learning and alternative learning. Fourth graders have 25 periods of subject-area learning per week, while eighth graders have 28 periods. Science, technology, and mathematics in fourth and eighth grade constitute approximately 10–15 percent of subject-area learning periods. In general, the duration of each period is 40 minutes in primary schools, and 45 minutes in junior high schools. However, the curriculum development committee in each school may adjust learning periods for each subject area, the duration of each period, and the number of weeks during a semester, to align with curriculum implementation and student needs.[11]

Instructional Materials, Equipment, and Laboratories

From 1968 to 1995, the National Institution of Compilation and Translation, a subdivision of MoE, published all textbooks in mathematics and science for primary and junior high schools. Article 8.2.1 of the 1995 National Education Law states, "All textbooks for primary and junior high school students must be approved by the educational authority and, if necessary, the educational authority may publish the official version of a textbook." The act thus permits teaching materials to be edited and published by either private publishers or the National Institution of Compilation and Translation. Since 1996, the curriculum development committee in every school has been able to select their own teaching materials from various versions of textbooks approved by MoE.[12]

Use of Technology

The application of technology in education benefits teaching and learning. Thus, in 2001, the Ministry of Education announced the Blueprint for Information Education for Primary and Secondary Schools to encourage the application of information technology in subject-area learning for primary and secondary students. Students are required to take computer literacy classes and are often assigned tasks, which require them to collect information on the Internet.[13, 14]

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Generally, teachers in primary schools teach all subjects. No specialist teachers for mathematics and science are employed until the seventh grade. However, rural-urban and large-small school disparities exist in primary schools. In cities such as Taipei City and in large schools, primary students may have specialist teachers for science.

Teachers and Teacher Education

In Taiwan, three types of pre-service teacher education programs are available: education for secondary teachers, for primary teachers, and for kindergarten teachers. Before 1994, primary school and high school teachers were educated only in normal schools, normal colleges, and normal universities.[15] In 1994, the Teacher Education Act replaced the Normal Education Act and deregulated teacher education. This act enabled all universities, as well as teacher colleges, to establish teacher education programs to produce K–12 teachers. Currently, 61 colleges and universities provide pre-service teacher education programs.

The Teacher Education Act Enforcement Rules, amended in 2003, establish the requirements for teacher certification.[16] Prospective teachers must complete a pre-service teacher education program, which includes compulsory specialized subject matter (discipline) courses, education concentration courses, and a six-month practicum. These specialized courses aim to develop teachers' professional knowledge and skills in one subject area. Education concentration courses include both pedagogical and pedagogical subject-specific courses. To teach most subjects in junior high school, pre-service teacher education students must complete 30–40 credit hours of subject matter courses and 26 credit hours of education concentration courses. Prospective primary school teachers are not required to take subject matter courses, but they must complete 40 credit hours of education concentration courses, including mandatory pedagogical subject-specific courses for three or four different subjects. The curricula of subject matter courses and education concentration courses must be approved, both by a teacher education committee at every university and by the Ministry of Education.

Requirements for Ongoing Professional Development

The same institutions that provide pre-service teacher education are also responsible for the professional development of teachers. Prior to 2003, both primary school and secondary school teachers were required to complete a minimum of 90 hours of professional development courses every five years. However, these regulations were abolished in 2003, and local bureaus of education now regulate teacher professional development programs.

Monitoring Student Progress in Mathematics and Science

In previous decades, the Joint Public Senior High School Entrance Examination was the main channel for junior high school graduates to gain admission to senior high school. However, under educational reform, this entrance examination was abolished in 2001 and replaced by a more flexible entrance system called the Multi-route Promotion Program for Entering Senior High Schools.

Under the Multi-route Promotion Program, students may take one of three routes to enter into senior high school: selection by recommendation, application, or assignment.[17] For all three routes, students must take the Basic Competency Test, which emphasizes fundamental knowledge and skills. Given twice a year, this test covers five subjects (Chinese, English, mathematics, natural science, and social science), and senior high schools use students' scores as the main selection criterion for admission.[18] When a student takes the route of selection by recommendation or application, evidence demonstrating his or her abilities is required in addition to the results of the Basic Competency Test. For the selection by recommendation route, the student also must do the following: present a recommendation from his or her junior high school; participate in a performance assessment, such as a laboratory practical, oral presentation, or performance; and be interviewed. Students unable to obtain a recommendation from their junior high schools may take the Basic Competency Test and apply to one senior high school. Students not accepted into senior high school through either the recommendation or application route are assigned to a secondary school on the basis of their test scores and school preference.

In addition to the system of senior high education the Practical Technical Program provided by vocational schools is available for students who wish to begin their professional careers at an early age.[19] One year of technical training courses is offered during the third year of junior high school. Following graduation, students may enroll in vocational schools for an additional year of technical training courses combined with an industrial practicum. Although the second year of training is voluntary, the additional training provides improved opportunities for students to find good jobs.

Impact and Use of TIMSS

Taiwan has participated in TIMSS four times since 1999. During this period, important curriculum reform was undertaken, with the Grades 1–9 curriculum guidelines being implemented for all grades of students in 2004. Following implementation, debate ensued regarding the efficacy of this reform. However the results of TIMSS 2007 indicated that student academic achievement remained outstanding.[20]

Yet despite this high achievement, trend analysis of TIMSS across cycles has raised in-depth issues deserving further research. For example, the high percentage of eighth grade students in Taiwan with mathematics achievement below the intermediate benchmark has drawn educators' and policy-makers' attention.[21] Similarly, fourth and eighth grade students in Taiwan have reported higher dislike of mathematics and lower self-confidence in learning mathematics as compared to students in most other countries.

In response to these issues, the National Science Council and the Ministry of Education continue to call for proposals and to sponsor relevant research projects. Since 2001, the National Science Council has focused on assisting disadvantaged students to learn mathematics, and on enhancing the interest and self-confidence in learning mathematics and science of all students.[22, 23]

A special call for proposals in 2006 represents the substantial implementation addressing these issues.[24]

To date, TIMSS results have become one of the primary sources to evaluate the efficacy of mathematics and science education in Taiwan, and the basis on which to develop the future curriculum.[25]

Suggested Readings

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Croatia

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Introduction

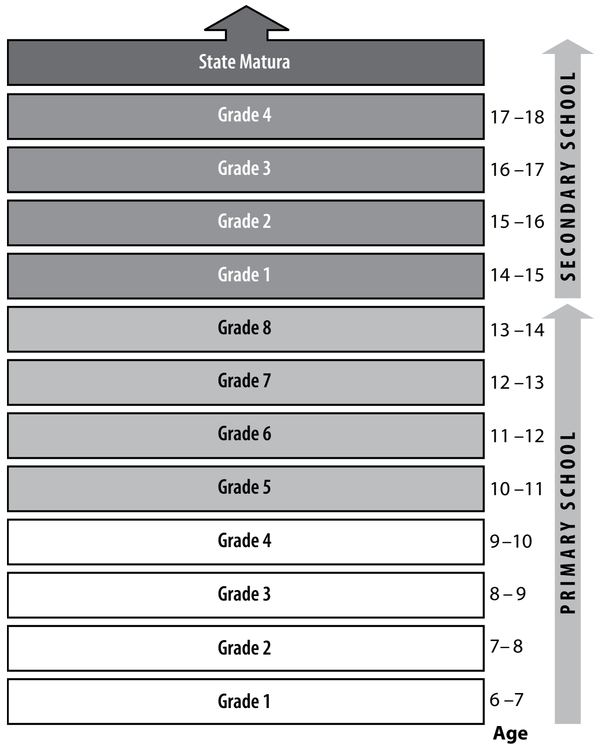
Overview of the Education System

In the Republic of Croatia, the Ministry of Science, Education and Sports is responsible for administration of the education system. Specifically, the ministry oversees activities related to the following: preschool, primary, and secondary education in the country and promoting international cooperation of education abroad; curriculum; textbooks and educational standards; development of the education system; professional development and teacher education for nursery, primary, and secondary school teachers; student standards; inspection and professional and pedagogic oversight; establishment of educational institutions and monitoring their compliance with the law; securing financial and material conditions for work in education; qualifying children, youth, and adults for acquiring technical knowledge and skills, and activities of various associations in its domain. The ministry also performs additional activities related to the following: curriculum design for higher education domestically and abroad; securing financial and material conditions for work; pre-service education and professional development of teachers; accommodation, food service, and other issues related to the student standards; and inspection in higher education. Lastly, the Ministry of Science, Education and Sports provides the most financial support for the education sector, although other ministries and local governments also allocate funds for education.

The education system in the Republic of Croatia consists of the following levels: preschool education, primary education, secondary education, and higher education (see Exhibit 1).

Preschool education encompasses education and childcare for children ages six months to six years (school age). It is realized through educational, health, nutritional, and social care programs. Although preschool education is not compulsory, data indicate that 99.6 percent of children were enrolled in preschool education programs during the 2009–10 school year, both as part of regular nursery programs and pre-school programs in the year before primary school.[1]

Exhibit 1: Educational Cycles for Acquiring Key Competencies



Primary education lasts eight years (Grades 1–8) and is compulsory and free for all children between the ages of six and fifteen. Children must be six years old by the end of March to enroll in school the following September. Primary education consists of three segments: compulsory education, provided in regular primary schools and special institutions for students with developmental difficulties; art education, provided in primary music and dance schools; and adult education at the primary level, provided in regular schools and specialized institutions. Music education also is conducted in certain regular primary schools as a separate educational program.

Secondary education (Grades 1–4) enables all students, under equal conditions and according to each student's capabilities, to acquire knowledge and skills required for work or continuing education. Secondary schools vary based on the type of instruction plan and program offered, and include the following types: gymnasium (general or specialized), vocational or trade schools (technical, industrial, trade, and others), and art schools (music, dance, visual arts, and others).

The Republic of Croatia considers quality higher education to be a precondition for a successful society. Therefore, the Ministry of Science, Education and Sports seeks to foster an intellectual base which will effectively implement quality higher education via Croatia's universities, and two- and four-year colleges.[2]

Regarding mathematics and science specifically, the activities of the Ministry of Science, Education and Sports are focused on the financial and material support of the following: science and research projects, scientific studies, international and domestic scientific conferences, and vocational congresses. However, no special government funds are allocated for mathematics and science teaching and learning other than the amount allocated for education in general for all subjects. Mathematics is a core subject and is strongly emphasized in the school curriculum; all methods of external evaluation, such as national examinations and the state *Matura*, include mathematics as a compulsory subject.

The Croatian Mathematical Society is the principal professional association of mathematicians in the country.[3] The association's goal is to improve and promote the mathematical sciences, the teaching of mathematics at all levels, the application of mathematics in other disciplines, and the social status of mathematicians as a whole. Furthermore, the association publishes the journal, *Matka*, for students of primary and secondary school and the electronic journal, *math.e*, for students and faculty members. In addition, many other local or county-level associations have their own journals and activities.

Languages of Instruction

The official language in the Republic of Croatia is Croatian. In some areas of Croatia where ethnic minorities live, the minority's language is the second official language. Languages used in class can be categorized into two groups: so-called territorial or minority languages, and non-territorial languages (consistent with the European charter on regional or minority languages).

Members of national minorities are guaranteed the right to education in their language as defined by the constitution of the Republic of Croatia, the constitutional law on the rights of national minorities, and the law on education in the language of national minorities. These individuals can exercise their constitutional right to education in their mother tongue via three basic models and three specialized educational frameworks:

1. Model A Schools—Classes are conducted in the language of a national minority, with compulsory learning of Croatian language for the same number of hours in which the mother tongue of national minority is conducted (Czech, Hungarian, Serbian, and Italian);

2. Model B Schools—Classes are conducted bilingually, with science subjects taught in Croatian and social science subjects taught in the minority language (Czech or Hungarian);
3. Model C Schools—Classes are taught in Croatian, with an additional 2–5 school hours designed to foster the language and culture of national minorities (Albanian, Austrian, Czech, Hungarian, Macedonian, Slovak, Slovene, Serbian, Ukrainian, and Rusyn);
4. A Class Framework—The language of the national minority is taught as the language of the social environment;
5. Special Classes (e.g., summer school, winter classes, correspondence classes); and
6. Special Programs (e.g., for the inclusion of Roma students in the educational system).

Members of national minorities propose and choose a model and program in line with existing legislation and their ability to complete the program. All models and frameworks are part of the regular education system of the Republic of Croatia. The Ministry of Science, Education and Sports currently oversees the implementation of the national program for the Roma.[4]

Mathematics Curriculum in Primary and Lower Secondary Grades

In 2005, the ministry began implementing a school reform project known as the *Croatian National Education Standard (Hrvatski nacionalni obrazovni standard).* The project marked the beginning of qualitative changes in primary school program content and introduced a new approach to teaching in primary schools that focused on students rather than on content. Within the project, an experimental syllabus was introduced in 5 percent of all primary schools during the 2005–06 school year. In accordance with recommendations of teachers who taught the experimental program and three subsequent professional revisions, subject committees created the *Syllabus for Primary School (Nastavni plan i program za osnovnu školu*). The syllabus was implemented in August 2006 and contains the educational work plan for subjects from Grades 1–8. The *Syllabus for Primary School*, however, is not presented in the form of a curriculum, but rather as a catalogue, with education goals described for separately each subject, grade, and teaching unit.[5]

According to the syllabus, students should be able to do the following by the end of fourth grade:

- Number—(Whole Numbers) Add, subtract, and compare whole numbers up to one million; demonstrate knowledge of place values; find values on a number line; add and subtract using a number line; differentiate between natural and ordinal numbers; estimate and round two-digit numbers to the nearest ten; recognize multiples and factors of numbers; learn the multiplication table up to 10 × 10; multiply a two-digit number by 100; divide multiples of 100 by 100; multiply a two-digit number by a number with more than two digits; divide a three-or-more-digit number by a two-digit number; perform operations with and without brackets; perform money calculations (in kuna and lipa); know units for measuring liquid (deciliter and liter) and convert between them; and know units for measuring mass (gram, dekagram, and kilogram) and convert between them. Basic algebra terms are included in curriculum up to fourth grade, and students learn that letters represent numbers in algebraic equations. (Fractions and Decimals) Use words to express fractions (e.g., one-third of an apple, 5 is half of 10); and divide with a remainder. Fractions, decimal numbers, and understanding of decimal place are not included in the curriculum up to the fourth grade. (Number Sentences with Whole Numbers) Solve word problems and simple equations. (Patterns and Relationships) Find a missing term in a sequence.

- Geometric Shapes and Measures—(Points, Lines, and Angles) Differentiate among and draw flat, curved, and broken lines; draw and label lengths, and mark terminal points of lines; draw horizontal and vertical lines; draw straight lines that intersect and determine their intersection point; differentiate between points that belong to a line from points which do not; recognize and draw right, acute, and obtuse angles; use informal coordinate systems (square grids) to locate points on a plane; and draw circles with a compass; and (two- and three-dimensional shapes) recognize and name two-dimensional geometric shapes (circle, triangle, rectangle, and square); recognize and name three-dimensional geometric shapes (sphere, cylinder, cube, parallelepiped, and pyramid); draw and name triangles according to shape (scalene, isosceles, and equilateral); correctly draw right triangles; measure the perimeter of triangles; measure the perimeter and area of rectangles and squares; know units for measuring area (cm^2, dm^2, and m^2); use a square grid to measure area; estimate areas and volumes; calculate the volume of cubes and parallelepipeds; and know units for measuring volume (cm^3 and dm^3). Axis of symmetry and rotational symmetry are not included in the curriculum up to the fourth grade.

- Data Display—Read, interpret, organize and represent data in simple tables, compare information from bar graphs, and draw conclusions from data. Up to the fourth grade, students do not learn to use diagrams and figures, but only simple tables and bar graphs displayed as pictures.

By the end of eighth grade, students should be able to do the following:

- Number—(Whole Numbers) Compare, round, add, subtract, multiply, and divide whole numbers; find numbers on number line; determine the absolute value of a whole number; write, read, compare, add, subtract, and multiply natural numbers larger than 1,000,000; divide by two-digit numbers; use the commutative, associative, and distributive properties of multiplication; know the properties of divisibility; determine common multiples; use pocket calculators; and find square roots using a calculator; (Fractions and Decimals) find fractions, decimals, and rational numbers on a number line; compare, add, subtract, multiply, and divide fractions; write equivalent fractions; convert fractions to mixed numbers; understand decimal places; compare, round, add, subtract, multiply, and divide decimals; convert decimal numbers to decimal fractions and vice versa; and write rational numbers as fractions and decimal numbers and compare them; (Integers) differentiate between positive and negative integers; find integers on a number line; compare, add, subtract, multiply, and divide integers; and determine the absolute value of an integer; and (Ratio, Proportion, and Percent) recognize proportional quantities and apply ratios and proportionality in simple everyday situations; present proportionality graphically; calculate percents; and determine interest.

- Algebra—Solve simple mathematical formulas and expressions containing one variable; solve simple linear equations and simple two-variable systems of two linear equations, and use substitution to verify the accuracy of the solution; substitute numerical values for variables in formulas and calculate the value of the remaining variable; present simple numerical relationships (e.g., linear, pure quadratic, and square root) using correct vocabulary, associated value tables, equations, and graphics; convert a simple word problem into algebraic notation (e.g., numerical sentences, linear equations, and systems of two linear equations), plan and execute its solution, and understand the significance of the solution; solve equations graphically and algebraically; graph linear functions; calculate with exponents; and perform calculations using scientific notation.

- Geometry—Measure and draw angles; construct angles using the properties of angle bisectors; identify, create, compare, and classify two- and three-dimensional geometric shapes and recognize and describe their geometrical properties, including translation, axis symmetry, central symmetry, and rotation; recognize congruence, similarity, and symmetry in two- and three-dimensional forms; apply Thales' Theorem for right angles inscribed in circles; apply the Pythagorean Theorem related to the measurable features of squares, rectangles, equilateral triangles, isosceles triangles, rhombi, and trapezoids; use the Cartesian coordinate system and read the coordinates of points in the system, determine perpendicular lines and planes; and apply formulas to determine length, area, surface area, perimeter, and volume.
- Data and Chance—Collect, classify and interpret data using tables, frequency diagrams, bar graphs and pie charts; determine the number of possible and favorable outcomes in simple situations; apply the terminology of probability; draw frequency and relative frequency histograms as well as find the arithmetic mean, median, quartiles, mode, range, and interquartile range of a series of numerical data; and calculate the probabilities of random events and explain them as relative frequencies.

Science Curriculum in Primary and Lower Secondary Grades

As with the mathematics curriculum, the *Syllabus for Primary School* (*Nastavni plan i program za osnovnu školu*) contains the educational work plan for science topics and subjects for Grades 1–8. Specifically, by the end of fourth grade, students should be able to do the following:

- Characteristics and Life Processes of Living Things—Differentiate between the living and the non-living world and recognize their correlation; recognize parts of the body and understand that the human body is an organism; recognize changes in the body during puberty; describe the main parts of plants and understand their main functions; understand the importance of plants for life; differentiate animal species according to their diet; explain mutual dependencies between plants and animals; recognize plants and animals that live in grasslands and understand their mutual relationship; know the most common forest animals; recognize the interdependence of plants and animals in the forest; understand the significance of water for humans, plants, and animals; and recognize the most common plants and animals in fresh water and in and near the sea.

- Life Cycles, Reproduction, and Heredity—Name members of a family and differentiate between members of the nuclear and extended family; differentiate between ancestors and descendants; and become familiar with the life cycles of living things.
- Interaction with the Environment—Differentiate among the seasons and recognize their main features; describe the changes of seasons and link them with the changes in the lives of plants, animals, and the activities of people; and understand the interrelationship among professions, institutions, plants, and animals in Croatia.
- Ecosystems—Recognize that plants need the sun and food; identify simple food chains; recognize human impact on the environment and how to separate waste into appropriate containers; understand the correlation between people's activities and pollution; understand man's impact on water conservation and consumption; and understand the importance of protecting the air and sea from pollution. Students do not learn about desert animals and rainforests up to the fourth grade.
- Human Health—Understand the importance of personal hygiene, a healthy diet, and maintenance of health; become acquainted with health care facilities and staff; describe how one can maintain health by adhering to basic hygienic, dietary, and physical habits; understand how infectious diseases are transmitted; and recognize maltreatment and ask for help.
- Classification and Properties of Matter—Describe physical states and properties of water by conducting simple experiments; describe characteristic differences in shape and volume of each state of matter, and understand that state changes can occur by heating or cooling; identify observable changes in materials caused by heating, cooling, and freezing; give examples of materials that dissolve in water and those that do not; and identify properties of air by conducting experiments, and determine the composition of air. Properties of metals and their use are not included in the curriculum up to the fourth grade.

- Energy—Identify sources of energy (the sun, electricity, water, wind) and describe practical uses of this energy; identify common light sources (the sun); and describe the concepts of rainbow and shadow. The following topics are not included in the curriculum up to the fourth grade: heat transfer from one object to another; electrical pathways and objects that conduct electricity; magnets and their properties; and gravity and forces that cause objects to move, and the idea of relative weight.

- Earth's Structure, Physical Characteristics, and Resources—Recognize features of the landscape in Croatia (lowland, hill, mountain, and coastland); describe elements of the natural environment in students' own town or village regions; perceive the correlation between climate and living things; name the most common types of wind; understand importance of air for life; identify evidence that air contains water; differentiate among types of soil; differentiate among types of forests; differentiate among types of water; identify the role of the land in the economy and explain the economic importance of different regions; and recognize the importance of using Earth's resources responsibly.

- Earth's Processes, Cycles, and History—Describe the movement of water on the Earth's surface; understand the water cycle; observe changes in nature due to seasons; and understand basic terms associated with fossils.

- Earth in the Solar System—Recognize the relationship between the sun and life on Earth; describe the solar system as a group of planets, including Earth, each revolving around the sun; identify the sun as the source of heat and light; and relate daily patterns observed on Earth to Earth's rotation on its axis (day and night, appearance of shadows).

By the end of eighth grade, students should be able to do the following:

- Biology—Describe types of living things and classify organisms on the basis of major taxonomic groups and their characteristics; describe the structure and functions of plants and animals; describe organs in the human body, their functions, and the most common disorders associated with organ systems; describe how the nervous system and hormones control processes in the human body; compare structures and functions of human organs and body systems with those of other animals; describe the main parts and life cycles of the cell and the role of metabolic processes in the cell; differentiate between unicellular and multicellular organisms, and understand the processes of cell division and photosynthesis; describe life cycles of plants and animals;

differentiate between asexual and sexual reproduction; recognize the importance and hereditary role of genes; recognize the evolutionary development of living things and explain the process of the emergence of new species, describe the adaptation of living things to specific types of habitats, and explain how changes in the environment can affect them; describe the importance of fossils; describe the interdependence and adaptation of living things in ecosystems and how changes in nature and human activity affect ecosystems, anticipating possible consequences of the effects at the local and global levels; describe food chains and explain the relationship between producers, consumers, and decomposers; describe causes of common diseases, addictions, and other factors that jeopardize human health and life; understand immunity; and explain the principles and importance of health protection.

- Chemistry—Examine and explain physical properties of substances via experiments (density, thermal and electrical conductivity, magnetic properties, solubility, boiling point, and melting point); differentiate between chemical and physical changes; explain chemical changes; describe how chemical reactions may be used as sources of energy; differentiate between metals, non-metals, and chemical compounds; recognize properties of acids and bases; differentiate between pure substances and mixtures; recognize homogeneous and heterogeneous mixtures and methods for separating mixtures; describe the structure of an atom and a molecule; describe factors that affect the process of dissolving or making solutions; recognize the physical properties of water and air; and recognize uses of oxygen.
- Physics—Describe transitions between states of matter by heating and cooling; describe various forms of energy and energy transformations; relate temperature changes to changes in volume; describe examples of heat transfer; identify basic properties of light; recognize characteristics of sound; construct and draw direct current circuits and explain the role of each part of the circuit; differentiate between conductors and insulators, understand applications of the magnetic effect of electric currents and uses of electromagnets; describe motion; describe types of forces and apply knowledge of forces to examples from everyday life; compare the density of substances; explore and apply levers; and explain pressure in terms of force and area.
- Geography—Name renewable and non-renewable energy sources and discuss their efficiency and environmental impact; describe methods of waste management; name causes of pollution; explain how common

methods of agriculture and land use can affect land resources; describe the importance of water conservation; describe the solar system; describe Earth's motion around the sun and the effects of this motion; recognize features of the structure of the Earth; describe earthquakes and volcanoes; describe uses of minerals and rocks; differentiate among types of soil; recognize characteristics of and the importance of water on Earth and Earth's water cycle; describe Earth's atmosphere; and describe changes in climate and weather patterns.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

The academic year is divided into two semesters. For the majority of students, classes are conducted on at least 175 school days (35 school weeks). For final-year students, classes are conducted on at least 160 school days (32 school weeks).

The time allocated for mathematics teaching in Grade 4 is four hours per week (i.e., 140 hours/year), while the time allocated for science is three hours per week (i.e., 105 hours/year). In Grade 8, mathematics is allocated four hours per week, or 140 hours per school year. Science in Grade 8 is allocated eight hours per week, two for each subject in the science area: biology, chemistry, physics, and geography. For better students, additional classes are offered; and, for students with lower marks, additional instruction is provided.

Instructional Materials, Equipment, and Laboratories

In primary schools and high schools, the Ministry of Science, Education, and Sports approves textbooks. Each April, the ministry publishes a catalogue of textbooks approved for the following year, with prices. Approval of new textbooks is conducted according to rules and regulations for textbook and handbook evaluation, correspondence with the textbook standards, and educational programs and goals. The School Textbook Board and expert committees for each individual subject or area are in charge of textbook selection.[6] Textbooks are not prescribed by the curriculum in Croatia, therefore the teacher has the freedom to choose a textbook; however, the textbook selected must comply with scientific, ethical, pedagogical, methodological, linguistic, and technical standards provided by the ministry.

Student textbooks come either alone or are accompanied by a workbook, exercise book, or other tools of instruction. A textbook is always accompanied by a teacher's manual. To enhance instruction, teachers may supplement approved textbooks with optional textbooks and other tools of instruction, with the consent of students' parents and the entire teaching staff. However, optional textbooks cannot replace approved textbooks and handbooks.

The State Pedagogical Standards list the minimum infrastructure and financial conditions for attainment and development primary school services. Schools are becoming better equipped with computers; however, equipping schools also depends on alternative financing, which varies from school to school and from county to county. Computers rarely are used in mathematics and science lessons.

Use of Technology

In recent years, the ministry has funded a program that provides each school with Internet service. The Hosting Service for Primary and Secondary Schools was designed for users within the school system, providing the ability to use basic network services and obtain electronic identities for all users in Croatian schools. Within the scope of this service, all schools, their employees, teachers, and students are provided free e-mail addresses and access to CARNet (Croatian Academic and Research Network) webmail.[7]

The *State Pedagogical Standards for Primary Education* (*Državni pedagoški standard osnovnoškolskog sustava odgoja i obrazovanja*) provides standards for the construction and equipping of primary schools. The teaching standards provide the following equipment at the school level: installation of phones, Internet and intranet service, alarm systems, video surveillance, digital cameras, photocopiers, interactive whiteboards, LCD projectors, blackboards, desks, chairs, microscopes, test tubes, and cabinet shelves.

The Syllabus for Primary School does not mention the use of personal calculators in Grades 1–4. In fifth grade, one of the educational goals is to instruct students to use standard calculators for simple operations. One change introduced in the new Syllabus for Primary School was to remove the requirement that students do operations with large numbers without using a calculator. The topic of calculator use in the classroom is still the subject of much debate; teachers share no universally accepted attitude about their use in school.

The Republic of Croatia also has established the E-islands Project, a distance learning program aimed at stopping or reducing negative demographic trends in the lightly inhabited or depopulating Croatian islands. Instruction is provided virtually to 17 island schools that are connected to five schools on the mainland wirelessly as well as to the CARNet backbone.[8]

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Class teachers conduct classes in all subjects during the first four grades of primary school, as well as English and German as a foreign language if they had opted for the language during their course of study. In cases where teachers did not opt for the language course of study, a specialist teacher conducts foreign language instruction. Specialist teachers conduct classes in religion, in all four grades, and music in the fourth grade. Beginning at the fifth grade, students have specialist teachers for all subjects, including mathematics and science, the latter of which is taught as four subjects: biology, chemistry, physics, and geography.

Homework Policies

Curriculum planning and programming requires consideration of each student's level of engagement at school (school work) and at home (homework), but the curriculum does not contain a statement about the assignment of mathematics or science homework. Homework is very common, both in primary and secondary schools, but there is a great deal of variety among teachers regarding the amount of homework assigned. However, regular homework is usually assigned in science, and especially so in mathematics. Teachers who teach Grades 1–4 usually give their students homework every day, except Friday.

Teachers and Teacher Education

Until the 2005–06 academic year, the majority of higher education institutions had a four-year undergraduate degree program. Through the implementation of the Bologna process at Croatian universities, study programs now have the following structure: a BA degree (a three- or four-year program ending with a diploma), and an MA degree (one or two years after the first cycle).

The government is responsible for the professional, pedagogical, and psychological training of teachers and their pre-service teacher education. In the Department of Teacher Education of the Faculty of Teacher Education, students enroll in the program for primary teacher education. This program lasts five years (10 semesters, or 300 credits) and upon completion students obtain a master's degree in primary education. At the end of the program, teachers may teach classes in all subjects in the first four grades of primary school, as well as English and German as a foreign language, if they had opted for the language course of study at the time of enrollment.

Specialist teachers in primary and secondary schools who teach biology, chemistry, physics, and geography must obtain a master's degree in their subject area, together with the required pedagogical, psychological, and methodological skills.

After completing their studies, all novice teachers are required to complete a one-year induction program under the supervision of a teacher-mentor. Following this period, the beginner teacher must pass the state certification examination in order to become a fully qualified and certified teacher.

Teachers have the right and the obligation to improve continuously and professionally through programs approved by the ministry. Indeed, teachers and other educational staff must take part in professional development at the national level at least once every two years, and at the county level at least three times per year.[9]

A wide variety of courses and other professional development activities are available for primary and secondary teachers. The Education and Teacher Training Agency (*Agencija za odgoj i obrazovanje*) provides professional assistance and guidelines, and regularly organizes professional development activities for educational staff.[10] As a result, individual and organized professional development is available in the scientific area as well as in the fields of pedagogy, didactics, educational psychology, methodology, information-communication technology, counseling, administration, educational policy, and other areas relevant for the effective and high quality growth and education of students.[11]

The government also finances supplementary professional education in areas defined as having major relevance to educational policy. Other continuing professional development is the employers' responsibility. Costs incurred by teachers' continuing professional development are co-financed by the government as a part of the statutory state aid for education.[12]

Monitoring Student Progress in Mathematics and Science

The Ministry of Education, Science, and Sports prescribe methods of monitoring and evaluation to measure the quality of all components of the national curriculum. The National Center for External Evaluation of Education is responsible for external evaluation within the Croatian education and training system, as well as conducting examinations based on national standards.[13] The Center conducts national examinations and delivers the results to schools. It encourages schools to conduct self-evaluation by providing assistance and support in the form of materials, advice, and training in the areas of external evaluation and self-evaluation.

The first national assessment in Croatia was conducted in May 2006 in first grade of the gymnasia. The subjects tested were Croatian language, mathematics, first foreign language (English, German or French), and Italian as mother tongue. In 2007, national examinations were conducted, in the first and second grades of gymnasia, and in the first grade of vocational schools. Tests in mathematics and the Croatian language of eighth grade students in primary schools were also administered during the same year. In 2008, students in the third grade of gymnasia and vocational schools took national examinations, as did students in the fourth and eighth grades of primary schools. Croatia intends to administer national examinations in upcoming years, though not according to any regular cycle. The next planned national examination will be administered in the subject of mathematics at the eighth grade of primary school.

The state *Matura* is a group of examinations administered in the same way and at the same time for all students, thus making comparative results at the national level possible. Students of comprehensive schools who are completing their secondary education take the state *Matura* exam. The content, conditions, manner, and procedure for taking the state *Matura* are stipulated in the Law on Education and Training in Primary and Secondary Schools (Official Gazette No. 87/2008) and the Regulation on Taking State Matura (Official Gazette No. 97/2008). The state *Matura* consists of a set of two part examinations: mandatory and optional. All students must take examinations in mathematics, Croatian language, and foreign language (from elementary through advanced levels). According to the Regulation on State Matura exams (*Pravilnik o državne mature*, Official Gazette No. 127/10), students concurrently educated in an ethnic minority language and in Croatian must take an examination in the ethnic minority language; for the third mandatory subject examination, these students can choose between mathematics or foreign language.[14] Students in vocational and four-year art program, who complete their secondary education by preparing and defending final projects as organized and implemented by their secondary schools, may also take the state *Matura* examinations, should they wish to continue with higher education. Regulations on taking the state *Matura* are applicable to students who enrolled in Grade 1 of a comprehensive school or four-year vocational and art school in the 2006–07 school year.

The Regulatory Act on the Methods, Procedures, and Elements of Evaluation of Students in Primary and Secondary Schools (*Pravilnik o načinima, postupcima i elementima vrednovanja učenika u osnovnoj i srednjoj školi*) provides direction on the use of grades and evaluation criteria.[15]

Student achievement is monitored and evaluated throughout the school year. In Grades 1–4, about one month after the end of each unit, examinations are taken. The frequency of administration of written and oral tests, as well as the evaluation of homework, are dependent upon individual teachers.. Teachers evaluate student achievement and behavior, numerically grading student performance in subjects and descriptively grading student behavior. School grades are expressed in numbers and words. Each number is followed by a verbal description of the grade: 1—insufficient, 2—sufficient, 3—good, 4—very good, and 5—excellent. The descriptive grades for student conduct are exemplary, good, and bad. In the first four years of primary school, grades are expressed numerically, accompanied by a clear written explanation of these grades and their meaning. For students of this age, descriptions of success or failure are easier to understand than an abstract numeric grade.

Students are assessed in terms of overall success. If at the end of the school year a student has the grade 1–insufficient in at least three subjects (e.g., due to not passing corrective exams by prescribed deadlines), then the student is required to attend the same grade level a second time. All other students who have positive grades are allowed to proceed to the next grade level. An exception to this policy is that students in primary Grades 1–3 who have an insufficient grade in only one subject may enroll in the next grade level.

Suggested Readings

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The Czech Republic

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Introduction

Overview of the Education System

Responsibility for schools in the Czech Republic is distributed among the Ministry of Education, Youth and Sports, regional education authorities, and municipalities. The ministry sets policies and assesses the state of the development of the education system. For example, the ministry defines compulsory educational components, is partially responsible for funding public schools, and oversees the school register, a tool used to ensure that all students have access to appropriate educational opportunities. The ministry also oversees institutions that provide professional development for teachers.

Between 2001 and 2003, regional education authorities were established, fundamentally decentralizing the education system. The Ministry of Education, Youth and Sports retained its policymaking responsibilities but transferred administrative responsibilities to the regions. After decentralization, regions assumed responsibility for secondary schools and post-secondary technical schools. Municipalities are responsible for nursery schools and for Basic Schools, which provide compulsory primary and lower secondary education, and guarantee their funding (except for salaries and instructional equipment, which are funded by the federal government). The federal government is responsible for educational institutions related to institutional or preventive care.

Nursery schools provide education for students ages 3–6 as part of preprimary education. Attendance is not compulsory, but 84 percent of children in this age group enroll, with 91 percent of children ages 3–6 attending the year prior to compulsory schooling. This final year of preprimary is free of charge and children have a legal right to attend.[1] Public schools do not charge tuition, but parents may be asked to pay up to 50 percent of operating costs.

Basic Schools provide nine years of education for the primary and lower secondary levels, and attendance is compulsory. The primary level lasts five years for students ages 6–11, and the lower secondary level lasts four years for students ages 11–15. At the end of the primary level (fifth year), students can leave Basic School to start an eight-year track of general secondary school (eight-year gymnasium). Similarly, at the end of the seventh year of Basic School, students can start a six-year gymnasium after passing an entrance examination set by the school. Approximately 11 percent of students study in one of the multiyear gymnasium programs.

Three kinds of schools provide upper secondary education: gymnasium schools, providing general academic programs for students ages 15–19; secondary technical schools for students ages 15–17, 18, or 19; and secondary vocational schools also for students ages 15–17, 18, or 19. Prerequisites for acceptance into upper secondary schools include successful completion of compulsory education and meeting entrance requirements set by schools. The gymnasium, technical school, and four-year vocational study programs all end with a final examination and certification that allows students to apply for post-secondary studies.

Private schools, both primary and secondary, were first established in 1990 (private universities in 1999). These schools are mostly secular and are usually established by for-profit or non-profit grant-aided organizations. Non-governmental Basic Schools (private and parochial schools) represent only 2.9 percent of the total number of Basic Schools and educate 1.5 percent of students at that level. In contrast, non-governmental secondary schools comprise 25.3 percent of all secondary schools and educate 15.3 percent of the students at that level.[2] Private schools receive a state contribution toward their operating costs. This funding is formula-based and the method of calculation is still under development. School fees and other private sources cover capital expenditures and rent.

Languages of Instruction

The official language of the Czech Republic is Czech, and the population is linguistically homogeneous. In 2009, immigrants (mostly Slavs) represented 4 percent of the population, although immigration has doubled in recent years.[3]

The language of instruction is Czech. However, students of ethnic minorities are guaranteed the right to education in their mother tongue to the extent appropriate for the development of their ethnic community. Schools for national minorities exist through the upper secondary level. With the exception of Poles, the minority population is scattered throughout the country, which is why the only minority-language schools in the country are Polish.

The Czech Curriculum in Primary and Secondary Schools

In 2004, the Education Act established a two-level structure for educational programs (state and school levels). Since September 2007, instruction has followed the *Framework Educational Program for Elementary Education* (FEP EE).[a] FEP EE, produced at the central level, specifies the concrete objectives, form, length, and basic curricular content of education as well as general conditions for their implementation.[4, 5] FEP EE defines nine main educational areas (consisting of one or more educational fields), cross-curricular themes, and supplementary educational fields. School education programs provide the framework for implementing education in individual schools. Each school head devises a school educational program in accordance with FEP EE that is adapted to the school's individual context. That is, each school creates its own education program comprising the expected outcomes and topics taught in each subject.

Primary education (Stage 1) is subdivided into Cycle 1 (Grades 1–3) and Cycle 2 (Grades 4–5), and lower secondary content identifies the expected outcomes for students at the end of Grade 9.

Mathematics Curriculum in Primary and Lower Secondary Grades

Mathematics at the primary level follows FEP EE and is divided into four thematic areas relating to Mathematics and Its Application: Numbers and Arithmetic Operations, Data and Relations, Plane and Spatial Geometry, and Problem Solving. Exhibit 1 presents what students should be able to do in each content area by the end of the fifth grade.

Exhibit 1: Mathematics Content Areas and Capabilities by End of Grade 5

Content Area	Capabilities
Numbers and Arithmetic Operations	Read, record, and compare natural numbers and read and compose statements of equality and inequality; use natural numbers to model real-life situations, count objects in a given set, and create sets with a given number of elements; use linear arrangement and represent numbers on a number line; perform oral and written arithmetic operations on natural numbers; round natural numbers, perform estimates, and verify the results of arithmetic operations on natural numbers; use commutability and associativity of addition and multiplication when performing both oral and written calculations; and create and solve problems which require the application of arithmetic operations on natural numbers.

a Two main sources—the Research Institute of Education of the Czech Republic and the Eurydice Network — describe the Czech educational system, using two different translations for the same educational program. The Research Institute of Education, which co-authored the Educational Program in the Czech language, uses the following translation: The Framework Educational Program for Elementary Education (FEP EE). The Eurydice Network provides information on and analyses of European education systems and policies, and uses the following translation: The Framework Educational Program for Basic Education (FEP BE). To maintain textual clarity, this chapter refers to FEP EE in all instances.

Content Area	Capabilities
Data and Relations	Understand the concept of time and perform simple time-unit conversions; describe simple relationships between real-world variables; gather, display, and classify data; and complete tables, charts, diagrams, and sequences of numbers.
Plane and Spatial Geometry	Draw basic plane figures (square, rectangle, triangle, and circle) and perform simple constructions; measure and estimate the length of line segments, add and subtract graphic line segments, and determine the length of a broken line or the perimeter of a polygon; construct parallel and perpendicular lines; determine the area of a geometric figure by means of a quadratic grid and use basic units of area; and identify and draw simple axisymmetric figures on a quadratic grid and determine the axis of symmetry by folding the paper.
Problem Solving	Solve simple practical word problems as well as non-routine problems.

Mathematics at the lower secondary level also is divided into four thematic areas: Numbers and Variables, Data and Relations, Plane and Spatial Geometry, and Problem Solving. Exhibit 2 presents what students should be able to do the following in each content area by the end of the ninth grade.

Exhibit 2: Mathematics Content Areas and Capabilities by End of Grade 9

Content Area	Capabilities
Numbers and Variables	Perform arithmetic operations on whole, natural, and rational numbers; square numbers and find square roots; round numbers, make estimates to a specified level of precision, and use calculators effectively; express whole-part relationships using natural numbers, ratios, fractions, decimals, and percentages; solve problems involving ratios and work with the graphic scales of maps and plans; solve problems involving percentages (including percentages greater than 100); describe simple real-life situations using variables, expressions, and equations, including simultaneous equations; and add, multiply, and factor polynomials.
Data and Relations	Gather, evaluate, and process data and compare data sets; determine direct or inverse proportionality; express functional relations with tables, equations, and graphs; and describe simple real-life situations with relations.
Plane and Spatial Geometry	Characterize and classify basic plane and spatial figures and identify their properties; determine the size of an angle by measurement or calculation; estimate and calculate the area and perimeter of basic plane figures and the volume and surface area of three-dimensional figures; perform constructions of figures in a plane; apply theorems about congruent and similar triangles in proofs and calculations; construct and characterize centrally-symmetric and axisymmetric figures; and solve application problems with geometry.
Problem Solving	Apply combinatory logic when solving problems, and use spatial reasoning to solve problems.

Science Curriculum in Primary and Lower Secondary Grades

The science curriculum in the primary grades (Grades 1–5) follows FEP EE and is divided into five thematic areas relating to Man and His World: Place Where We Live, People Around Us, Man and Time, Diversity of Nature, and Man and His Health. Traditionally, instruction following the framework in Grades 1–3 integrates subject matter from the five individual thematic areas into one subject. In Grades 4–5, instruction following the framework is divided into two separate subject areas: one subject drawing on the thematic areas Place Where We Live, People Around Us, and Man and Time as a foundation for geography and history; and one subject drawing on the thematic areas Diversity of Nature and Man and His Health as a foundation for the natural sciences. Exhibit 3 describes the topics covered in the subject traditionally used as a foundation for the natural sciences, which students will have covered by the end of fifth grade.

Exhibit 3: Natural Sciences Content Areas and Capabilities by End of Grade 5

Subject Area	Main Topics	Sub-topics
Diversity of Nature	Substances and Their Properties	Classification, properties, comparisons, and changes of substances; changes of state in matter; measuring quantities; and working with units of measurement.
	Water and Air	Distribution, properties, importance, and forms of water; the water cycle; characteristics, composition, and importance of air; and air circulation.
	Minerals, Rocks, and Soil	Economically important rocks and minerals, weathering, and the origin and importance of soil.
	Earth and the Universe	The solar system, day and night, and the seasons.
	Plants, Fungi, and Animals	What living things need to survive and characteristics that help them survive in particular environments, life cycles, nutrition, and the body structure and importance of familiar species.
	Living Conditions	Diversity of the conditions for life on Earth; importance of the atmosphere, water, soil, fauna, and flora; and climate and weather.
	Natural Balance	Relationships among organisms, and ecosystems.
	Conservation and Protection	Human responsibility toward the environment, conservation, and protection of the environment; waste disposal; and natural and ecological disasters.
Man and His Health	Human Body	What humans need to survive and characteristics that help them survive in particular environments; basic structures and functions in humans; and reproductive differences between males and females, the basics of human reproduction, and human development.
	Health	Exercise, nutrition, substance abuse, illness, minor injuries and wounds, first aid, injury prevention, personal and intimate hygiene, mental health, and stress and its risks.

The science curriculum in lower-secondary grades (Grades 6–9) follows FEP EE relating to the Man and Nature curriculum strand, which includes Physics, Chemistry, Natural Sciences, and Geography. Science topics covered by the end of ninth grade are presented in Exhibit 4.

Exhibit 4: Summary of the Man and Nature Curriculum, Grades 6–9

Subject	Main Topics	Sub-topics
Physics	Substances and Bodies	Measured quantities (length, volume, mass, temperature, and time) and states of matter (the connection between state of matter and particulate structure; and diffusion).
	Motions of Bodies and Forces	Uniform and non-uniform motion; rectilinear and curvilinear motion; gravity and gravitational fields; pressure and area; friction; addition and subtraction of force vectors; Newton's first, second, and third laws of motion; and equilibrium state for levers and fixed pulleys.
	Mechanical Properties of Fluids	Pascal's Law, hydraulic equipment, hydrostatic and atmospheric pressure (the relationship between hydrostatic pressure, depth, and the density of a liquid; and the relationship between atmospheric pressure and weather), and Archimedes' principle (buoyant force; immersion, suspension, and flotation of bodies in fluids at rest).
	Energy	Forms of energy (kinetic and potential energy, internal energy, electrical energy and power, production and transfer of electrical energy, nuclear energy, nuclear fission, nuclear reactors, nuclear power plants, and protection against radiation), state changes (melting and freezing, latent heat of melting, evaporation and condensation, factors influencing evaporation, and the boiling point for liquids), and renewable and non-renewable sources of energy.
	Sound	Properties of sound (propagation media, speed, reflection, echo, absorption, and pitch).
	Electricity and Light	Electric circuits, voltage sources, electric appliances, and switches; electricity and magnetism (electric and magnetic force, electric charge, thermal effects of electric currents, resistance, direct current motors, transformers, and safety); and properties of light (sources, speed in a vacuum and in various media, shadows, and solar and lunar eclipses; reflection, concave, and convex mirrors; imaging by refraction through thin converging and diverging lenses; and dispersion of white light by a prism).
	The Universe	The solar system (main components and phases of the moon), and the composition of stars.

Subject	Main Topics	Sub-topics
Chemistry	Observation, Experiment, and Chemical Safety	Properties of substances (density, solubility, thermal and electrical conductivity, and the effect of the atmosphere on properties and states of substances), and safety (in the school laboratory and in everyday life, risk and safety labels on chemicals and machinery, warning symbols, and industrial accidents).
	Mixtures	Heterogeneous and homogeneous solutions, concentration and saturation of solutions, solubility and factors affecting solubility (temperature, stirring, and surface area of solute), separation of components of mixtures (precipitation, filtration, distillation, crystallization, and sublimation), water (distilled, potable, waste water, drinking water production, and water purity), and composition and purity of air and the ozone layer).
	The Particulate Composition of Matter and Elements	Molecules, atoms (atomic nucleus, protons, neutrons, electrons, and electron shells), elements (names, symbols, properties and uses, the periodic table, groups, periods, and atomic number), and chemical bonds and nomenclature of simple inorganic and organic compounds.
	Chemical Reactions	The law of conservation of mass; chemical equations, moles, chemical reactions (combination, neutralization, exothermic, and endothermic), factors influencing the rate of chemical reactions (temperature, surface area of reactants, and catalysts), and electrochemistry.
	Inorganic Compounds	Oxides (nomenclature, properties, and uses), acids and bases (pH, properties, formulas, and names and applications of acids and bases), and chemistry of oxygen and halide salts (nomenclature, properties, applications, and oxidation state).
	Organic Compounds	Hydrocarbons (alkanes, hydrocarbons with multiple bonds, and aromatic hydrocarbons), fuels (petroleum, coal, natural gas, and synthetic fuels), hydrocarbon derivatives (alcohols and carboxylic acids), and natural substances (sources, properties, and examples of the functions of proteins, fats, saccharides, and vitamins in the human body).
	Chemistry and Society	The chemical industry in the Czech Republic (industrial fertilizers, heat-treated materials, plastics, synthetic fibers, detergents, pesticides, insecticides, combustible compounds, drugs, and addictive substances).
Natural Sciences	General Biology and Genetics	Emergence, development, and diversity of life and its significance (nutrition, respiration, growth, reproduction, development, and reactions to stimuli; views on the emergence of life), fundamental structures of life (cells, tissues, organs, organ systems, and unicellular and multicellular organisms), classification of organisms, heredity and mutability of organisms (transfer of hereditary information, genes, and crossbreeding), and viruses and bacteria (occurrence, significance, and practical application).
	Fungal Biology	Fungi without fruiting bodies (basic characteristics, positive and negative impact on humans and living organisms), fungi with fruiting bodies (structure, occurrence, importance, harvest, consumption, and first aid for mushroom poisoning), and lichens (structure, symbiosis, occurrence, and importance).

Subject	Main Topics	Sub-topics
Natural Sciences	Plant Biology	Plant anatomy and morphology (structure and significance of parts of higher plants: root, stem, leaf, flower, seed, and fruit), plant physiology (photosynthesis, respiration, growth, and reproduction), plant categorization (classification of common species of algae, bryophytes, pteridophytes, gymnosperms, and angiosperms; their development; and the use of economically important plants), and the importance and protection of plants.
	Animal Biology	Animal anatomy and morphology (animal cells, tissues, organs, organ systems, unicellular and multicellular organisms, and reproduction); animal evolution, development, and classification (protozoans, cnidarians, platyhelminthes, nemathelminthes, mollusks, annelids, arthropods, chondrichthyes, osteichthyes, amphibians, reptiles, birds, and mammals); distribution, significance, and protection of animals (economically and epidemiologically important species, raising domesticated animals, and animal communities); and animal behavior.
	Human Biology	Human reproduction; anatomy and physiology (structure and function of body parts, organs, and organ systems, including skeletal, muscular, circulatory, respiratory, digestive, excretory, reproductive, and nervous systems; higher nervous activity; and mental health); illnesses and injuries, and their prevention (causes, symptoms, essential knowledge and methods for treating common illnesses; serious injuries and life-threatening conditions); and lifestyle.
	Geology and Earth Science	Earth (origin and structure), minerals and rocks (formation, properties, qualitative classification, practical importance, uses, and principles of crystallography), endogenic and exogenic geological processes (causes and consequences), soils (composition, properties, and importance of soil for plant nutrition, economic importance, dangers and examples of soil devastation, options for and examples of re-cultivation), evolution of the Earth's crust and organisms on the Earth (geological changes, emergence of life, occurrence of typical organisms and their adaptation to the environment), geological development and structure of the territory of the Czech Republic (Bohemian Massif and the Carpathians), and climate and weather.
	Ecology	Organisms and their environment (relationships among and between organisms and their environment; populations, communities, natural, and artificial ecosystems; food chains; and balance within an ecosystem), and natural and environmental protection (global environmental problems and protected natural areas).
	Empirical Exploration of Nature	Empirical methods of exploring nature (observation with a magnifying glass, microscope, or telescope, simplified identification keys, and atlases) and important biologists and their discoveries.

Subject	Main Topics	Sub-topics
Geography	Geographic Information, Data Sources, Cartography, and Topography	Geographic and cartographic terminology (basic topographical formations, plans, maps, map terminology, statistical data, tables, and graphs); geographic data sources and geographic cartography and topography (globe, globe scale, geographic grid, meridians and parallels, geographic coordinates, determining geographic position); scale and content of plans and maps; orienting plans and maps with respect to the cardinal points; and practical exercises and applications using cartographic products in printed and electronic form.
	A Natural Image of the Earth	The Earth as a celestial body (the shape, size, and motions of the Earth, day and night, change of seasons, Universal Time, time zones, local time, International Date Line, and conventional time); landscape area (natural sphere, social and economic spheres, and components and elements of the natural sphere); the natural sphere on the planetary level (geographical belts, latitudinal zones, and altitudinal zones); and the system of the natural sphere at the regional level (natural regions).
	Regions of the World	Continents, oceans, and world macro-regions (criteria; natural and socio-economic conditions, with an emphasis on their links and connections: natural zones, climate zones, settlement areas, language areas, religious areas, and cultural zones); and natural, social, political, industrial, and environmental problems.
	The Social and Economic Environment	World population; globalization of social, political, and economic processes; the global economy; and regional social, political, and economic units.
	The Environment	Landscape (natural and social environment, types of landscapes); and the relationship between nature and society (long-term sustainable life and development, principles and fundamentals of natural and environmental protection, protected nature areas, and global ecological and environmental problems).
	The Czech Republic	Regions of the Czech Republic.
	Field Work	Field exercises in and observations of the local landscape, geographical excursions, and preservation of endangered life.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Materials, Equipment, and Laboratories

The *Framework Education Program for Elementary Education* (FEP EE) contains directives for equipping schools. At minimum, schools should have specific spaces dedicated to science and information and communication technology (ICT) instruction. Optimally, laboratory space should be created and furnished with equipment and tools specific to the subject taught in that space as well as appropriate audiovisual and ICT equipment. Students in primary grades conduct simple science experiments and make measurements using simple tools and devices. Students in lower secondary grades conduct more sophisticated experiments.

The Czech Republic has no specific requirements for teaching aids, but instructional materials must adequately address the needs of the students. The Ministry of Education, Youth and Sports publishes a list of approved textbooks and teaching texts in the *Bulletin of the Ministry of Education, Youth and Sports* and on the Internet. These materials comply with the educational objectives stipulated in the Education Act, the Framework Education Programs, and legal regulations.[b] Schools may use other textbooks and teaching materials that have been approved by the head of school.

Use of Technology

Instruction in ICT is included as a compulsory part of elementary education at both the primary and lower secondary levels. Programs focus on building elementary operating skills, familiarity with the world of information, working creatively with information, and using information in school and everyday life.

Students learn to use computational technology tools, especially calculators, computer software, and other aids in the context of mathematics applications. Students also become better at independent and critical work with information sources.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Usually, students first have specialist teachers for mathematics and science in sixth grade. Because science is taught as separate subjects, science teachers are specialized in biology, chemistry, physics, and Earth science. At the lower secondary level, teachers generally specialize in two subjects.

Homework Policies

The Czech Republic has no homework regulations.

Teachers and Teacher Education

Higher education institutions train Basic School teachers. Primary-level teachers (Grades 1–5) must have master's degrees, which generally take five years to complete at a school of education (usually a three-year bachelor's program followed by a two-year master's program). Graduates from these programs are qualified to teach all subjects at the primary level. Some programs allow prospective teachers to specialize in a chosen subject. Teacher preparation includes a practicum component that lasts from six to twelve weeks, depending on the school.

b For more information, visit http://www.msmt.cz

General subject teachers at the lower secondary (Grades 6–9) and upper secondary (Grades 10–13) levels also must have master's degrees. Most secondary teachers are specialists, however, and are usually qualified to teach at least two subjects. Secondary teachers are educated either at schools of education or at other higher education institutions in the subject they wish to teach (e.g., natural sciences, mathematics, or physics). Teacher preparation at this level also includes a practicum component lasting four weeks per field of study. A teacher who is fully qualified at the primary or secondary level may teach outside his or her area of specialization at the discretion of the head of school. At the end of their studies, teachers are qualified at the ISCED 5A level and, once they have passed a state final exam and defended their theses, obtain a university diploma, a diploma supplement, and the academic degree of *Magistr* (master).

Requirements for Ongoing Professional Development

A large number of organizations offer professional development. The Ministry of Education, Youth and Sports accredits educational institutions and programs focused on professional development. The head of school provides professional development for educational staff aligned with a plan developed with the relevant trade union (if there is one at the workplace). There are no requirements for professional development specific to mathematics, science, and technology.

Monitoring Student Progress in Mathematics and Science

Students at the primary and lower secondary levels do not take national or regional examinations. Schools use teacher-written tests to measure achievement and, while the use of standardized tests is not compulsory, most schools use some type of commercial test.

The evaluation of student educational outcomes is governed by Sections 51–53 of the Education Act and specified by a Ministry of Education, Youth and Sports decree that states that assessment shall be based on an evaluation of the extent to which a student has achieved the expected curricular outcomes in each subject.[6] Teachers assess students based on written and oral work, as well as homework. Teachers also conduct verbal assessments of student progress, describing and commenting in writing about students' strengths and weaknesses. After 1990, such verbal assessment became commonplace, especially in the younger grades, and was officially authorized in 1993. Since 2005, verbal assessments have been regulated by a Ministry of Education, Youth and Sports decree.

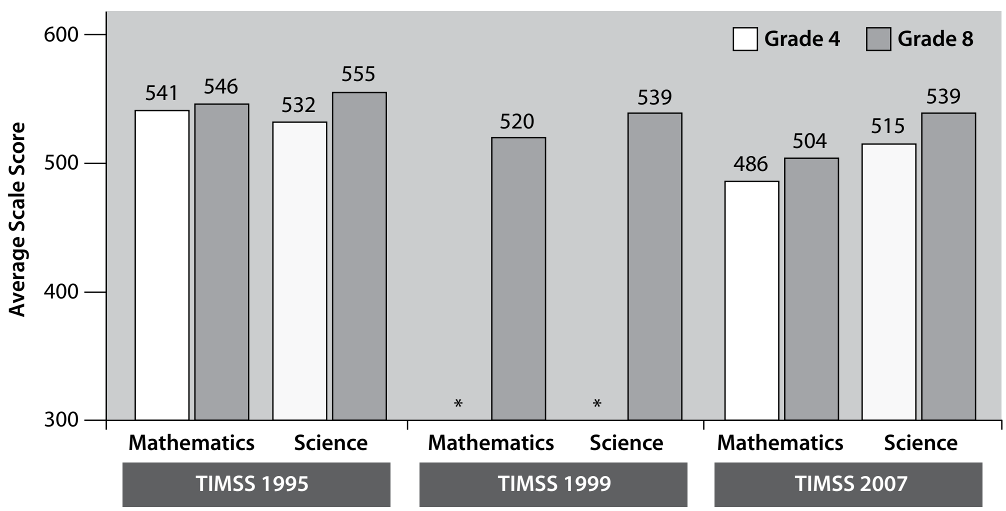
The results of these continuous assessments are summarized in a report at the end of each term. Most schools report student progress on a scale of 1–5 for written work and percent scores for oral work, with a score of 3 being satisfactory and a score of 5 being exemplary. Verbal assessments are included in this report as narrative.

Students who successfully pass all compulsory subjects are promoted to the next grade, while students who do not pass all compulsory subjects repeat the grade. Students may only repeat one grade at the primary level and one at the lower secondary level.

Impact and Use of TIMSS

In 1991, the Czech Republic became a member of IEA and in 1995 three groups of students participated in the first cycle of TIMSS: students in Grades 3 and 4, students in Grades 7 and 8, and students in their final year of secondary education. The Czech Republic also has participated in TIMSS 1999 and TIMSS 2007. In TIMSS 2011, only fourth grade students were tested. TIMSS average mathematics and science achievement in the Czech Republic over the three cycles are presented in Exhibit 5.[7, 8]

Exhibit 5: Trends in TIMSS Mathematics and Science Achievement in the Czech Republic



* Grade 4 not assessed in TIMSS 1999.

In 1995, Czech students scored significantly above the international average. However, data indicate a declining trend in student achievement, especially in mathematics. In 2007, average mathematics achievement at the eighth grade was mediocre and average mathematics achievement at the fourth grade was significantly below the TIMSS scale average of 500.

The achievement decline from 1995 to 1999 did not trigger a review of the education system, but the continued downward trend observed in 2007 provoked discussion at the ministry level about mathematics education. The Ministry of Education organized a special seminar about mathematics education entitled, "Basic Concepts of Mathematics Education, Especially in View of Czech Results from TIMSS and PISA." The Ministry of Education subsequently announced a public request for research analyzing factors influencing Czech student achievement in TIMSS 2007. Based on the results of this work, an expert group appointed by the Ministry of Education, Youth and Sports developed mathematics standards for elementary education. Currently, the ministry is preparing a national assessment for fifth and ninth grade students and discussing curricular revisions.

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Denmark

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Introduction

Overview of the Education System

In Denmark, education is compulsory and public schooling is free. Public preprimary, primary and lower secondary schools are combined into one unified school, called the School for the People (*Folkeskolen*). Although the Folkeskole Act centrally regulates the *Folkeskole*, municipalities decide how local schools will function in practice within this framework.[1]

The Folkeskole Act ensures that all public schools share common goals and provisions concerning what subjects are taught at different levels, the central knowledge and proficiency areas of those subjects, and standard regulations concerning the leadership and organization of the school system. Within these parameters, however, individual schools may have their own unique focus. Every school must have a school board with representation from parents, teachers, and students. The school board makes recommendations regarding the local curricula based on national guidelines. Once the local curricula receive final approval from the municipal board, they become binding for the individual school. The majority of municipalities in Denmark choose to have a common plan for all schools within the municipality.

At the beginning of the 2010–11 school year, approximately 715,000 students attended primary and secondary schools.[2] Eighty percent of all students attend public schools, 14 percent attend private independent schools, 4 percent attend continuation schools, and 2 percent receive instruction through other educational options (e.g., special education schools, treatment centers, or at home).[3] Private independent schools (*Frie Grundskoler*) are self-governing institutions that must adhere to public school standards. Continuation schools are private boarding schools that emphasize social learning and include subject areas such as sports, music, nature, and ecology. Continuation schools offer schooling in Grades 8–10 (and sometimes Grades 7, 11, and 12). Private independent schools and continuation schools receive a substantial state subsidy based on the number of students enrolled per school year;[4] parents pay the remaining fees.

The Danish school system is comprehensive in the sense that it includes preprimary (Grade 0 in Denmark, corresponding to kindergarten class), primary (Grades 1–6, corresponding to ISCED level 1), and lower secondary (Grades 7–10, corresponding to ISCED level 2) education.[5] Although lower secondary education mostly covers Grades 7–9, *Folkeskole* includes an optional Grade 10 year. The different grades are defined by age cohorts. When children start preprimary school, they meet the classmates they will be together with in all subjects for all ten or eleven years of schooling. There is no streaming, and grade retention is almost non-existent. The average class size is 19.6 students.[6]

Since August 2009, compulsory education has begun with Grade 0. The school year starts in August, and children attend Grade 0 the calendar year they turn six.[7] After Grade 0, compulsory education continues for another nine years, for a total of ten. The *Folkeskole* includes an optional eleventh year (Grade 10), and approximately 55 percent of students leaving ninth grade attend this optional tenth grade, either at the *Folkeskole*, a private independent school, or a continuation school.[8, 9] After compulsory education, students can choose from a variety of youth education programs (preparatory study or professional qualification programs) that are either academically or vocationally oriented, or both.

The introduction of the ministerial curriculum guidelines, the *Common Objectives* (*Fælles Mål*), in 2003 was a milestone for Danish schools.[10, 11] For the first time, the teaching objectives for each subject were no longer merely recommendations for the municipalities, but national goals that schools were required to follow. The *Common Objectives* establishes centrally defined objectives and intermediate and final achievement goals for each subject and describes the content of all subjects in the *Folkeskole*. However, because these guidelines define only the objectives and goals, not specific decisions about content and teaching materials, school practices vary throughout the country.

The Folkeskole Act stipulates that teaching must be organized in a way that focuses on the needs of the individual student—a requirement that encourages differentiated instruction.[12] In addition, schools provide special needs education and other social education assistance for students with special needs, including students with general developmental problems not receiving sufficient support from differentiated instruction alone.[13] In the 2008–09 school year, about 49,000 students (of a total of approximately 591,000 preprimary, primary, and lower secondary students) received special needs education in special classes or in their regular class.[14]

Teachers' main teaching objectives involve achievement goals for the class as a whole. Within the framework of these achievement goals, however, teachers also decide on individual learning goals that may apply to one student or a group of students. By formulating individual learning goals, the teacher fulfills the Folkeskole Act's requirement for maintaining an individual student focus. Teachers can also choose textbooks with activities that allow students to concentrate on their individual learning goals.

Languages of Instruction

The official language in Denmark is Danish, which also is the language of instruction in public schools and the majority of private schools. Very few private schools offer instruction in another language (e.g., Arabic, English, German, or French).

Since the 1960s, immigration from both Western and non-Western countries has resulted in an increasing number of people who speak Danish as a second language. In January 2011, immigrants constituted 9.8 percent of the Danish population, and immigrants from non-Western countries alone constituted 5.6 percent of the population.[15] Students study English as a foreign language in Grades 3–9 and either German or French in Grades 7–9.

Mathematics Curriculum in Primary and Lower Secondary Grades

The current national policies on mathematics and science and technology were published in the 2009 *Common Objectives*.[16, 17] This document defines the grade-to-grade structure in the primary and lower secondary curriculum that covers mathematics instruction: Grades 1–3, Grades 4–6, and Grades 7–9. As a result, separate guidelines do not describe mathematics objectives for individual grades. However, because the intermediate achievement goals for Grade 6 are required national goals, they also serve as the guidelines for Grade 4 mathematics instruction.[18] Moreover, students may encounter specific skills, such as division, at different points within the curriculum, depending on the municipality, the school board, the teacher, the school curriculum, and the teaching materials (e.g., textbooks).

Academic reading skills are a focus at every level. Furthermore, students are expected to be able to solve mathematical problems individually and in cooperation with other students. However, because it is often difficult to determine when students are introduced to specific subject-oriented goals, the skills described below are not necessarily introduced in a particular grade, such as the fourth or eighth grade. Instead, these skills are considered achievement goals within the grade-to-grade curriculum structure.

In *Common Objectives 2009,* the mathematics curriculum is organized into four central knowledge and skills areas: Qualifications, Topics, Applications, and Methods in Mathematics. Each category specifies what students are expected to know by the end of every grade-span level. For example, one achievement goal for Qualifications is that students know how to solve mathematical problems contextually. This skill gives students an opportunity to engage in intuitive thinking, to arrive at their own solutions, and to develop problem-solving skills.[19]

In the mathematics curriculum for Grades 4–6, the knowledge and skill area of Topics is divided into three subcategories: Numbers and Algebra (*tal og algebra*), Geometry (*geometri*), and Statistics and Probability (*statistik og sandsynlighedsregning*).[20]

- Numbers and Algebra—Specific materials and drawings form the basis for students' ongoing work with oral and written mathematical expressions. By the end of Grade 6, students should know rational numbers and how to use addition, subtraction, multiplication, and division. Decimal numbers and fractions are introduced on a practical level. Students should also be familiar with the concept of percent and be able to calculate simple percentages. Also, they should understand the relationship among decimal numbers, fractions, and percentages. The system of coordinates and the connection between numbers and visual displays also are introduced, as are simple equations. Students use calculators and computers to develop their skills in choosing appropriate calculation methods. Instruction incorporates verbal directions, multiplication tables, graphic representations, and coordinate systems to increase student knowledge of the diverse academic methods and materials that are available.
- Geometry—The teaching of geometry is based on everyday life. Students learn simple methods to calculate circumference, volume, and area, and they are introduced to basic geometric concepts such as angles, circles, and polygons. Students learn to rotate, reflect, transpose, and experiment with geometric shapes and patterns. Figures and diagrams as well as geometric and formal models are used to develop students' academic understanding.

- Statistics and Probability—Students are expected to be able to collect, process, and convey data from tables and diagrams, as well as to read, describe, and interpret the data and information. Students use calculators and computers to develop their skills in choosing appropriate calculation methods.

In the mathematics curriculum for Grades 7–9, the knowledge and skill area of Topics is divided into the same three subcategories: Numbers and Algebra, Geometry, and Statistics and Probability.[21]

- Numbers and Algebra—Students should be able to use numbers in both practical and theoretical contexts. Specifically, students should understand and use mathematical equations with variables.
- Geometry—Students should use geometric concepts and methods to describe everyday objects and phenomena. Specifically, students should be able to describe and perform calculations with three-dimensional and plane figures. Moreover, students should understand the connection between algebra and geometry.
- Statistics and Probability—Students should be able to apply statistical concepts to describe, analyze, and interpret quantitative data, as well as read, understand, and evaluate statistics and probabilities.

It is worth mentioning that in Denmark, 10–12 percent of students in the *Folkeskole* have extensive problems learning mathematics and need remedial education. Over 15 percent of students have difficulty solving more complex mathematical tasks.[22] Recent research has shed light on why so many students struggle in mathematics. One reason is teachers' lack of didactic knowledge. Another problem is the traditional structure and organization of instruction (e.g., doing problems from textbooks and checking the answers collectively). Remedial education is often based on the same structure as regular education, but with the use of textbooks one or two grades lower. As noted in the teaching guide for mathematics, "Many students do get help, but without a great difference." [23] Other research has found that these problems could stem from the fact that only 42 percent of the mathematics teachers in Grades 1–4 specialized in mathematics during their teacher training.[24] Furthermore, since the introduction of the *Common Objectives* in 2003, mathematics instruction has posed a much greater challenge to teachers than before; the subject is now defined as part of everyday life, and this connection must be made explicit during instruction.

Science Curriculum in Primary and Lower Secondary Grades

In primary school (Grades 1–6), science and technology is taught as an integrated subject, with the following grade-to-grade structure: Grades 1–2, Grades 3–4, and Grades 5–6. After Grade 6, students take physics and chemistry instead of the integrated subject. As with mathematics, this structure means that science and technology instruction is not prescribed specifically for Grade 4. Because the intermediate achievement goals for Grade 4 are compulsory national goals, they also serve as the guidelines for Grade 4 science and technology instruction.[25]

Unlike mathematics, the teaching of science and technology has always been based on practical application and exploratory methods. However, research indicates that science and technology instruction suffers from some of the same problems as mathematics—namely, teachers lack didactic knowledge and there is a relatively low percentage of teachers who have chosen to specialize in science and technology during their teacher education.[26] A report prepared for the government in 2003 states that teachers have inadequate professional qualifications to teach this subject.[27]

The curriculum for science and technology prescribes national achievement goals that encourage students to observe different kinds of natural phenomena in their everyday life, to ask questions about these phenomena, and to discuss their findings using concepts such as categorization, size, number, and weight.[28] Students must also be presented with numbers and patterns of numbers to practice interpretation of data.

The achievement goals for Grade 4 in the science and technology curriculum are divided into four categories: the Near Environment (*Den nære omverden*), the Distant Environment (*Den fjerne omverden*), Human Interaction with Nature (*Menneskets samspil med naturen*), and Working Methods and Ways of Thinking (*Arbejdsmåder og tankegange*).[29]

- The Near Environment—This category emphasizes connections, differences, and changes (e.g., the characteristics and changes in the local natural surroundings, weather, and seasons). Students learn about the construction and function of the human body and develop an understanding of their own physical needs. They are introduced to the food chain and are expected to understand and use the concept. Students also learn about animals and their habitats as well as how to categorize animals in systematic groups according to their characteristics. Students should develop skills through fieldwork with nature in their own communities and appropriate laboratory methods.

- The Distant Environment—Students work with physical, chemical, geographical, and biological elements. Instruction focuses on comparing near and distant surroundings to encourage general scientific curiosity and to increase scientific and technical knowledge and skills. Students learn about animals and plants from different countries. They should know about the living conditions and cultures of other people in comparison with their own and to give examples of living conditions in different climate zones. Students also learn about the seven continents and about regions and countries in their own part of the world, particularly the Nordic countries.
- Human Interaction with Nature—Students should develop knowledge of techniques which humans use to take advantage of natural resources. Classroom instruction is supplemented with visits to companies, farms, and museums.
- Working Methods and Ways of Thinking—Students should learn how to plan and describe simple experiments and studies. By organizing and categorizing data, students should develop an ability to understand and communicate results.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

The Danish Ministry of Children and Education prescribes a minimum number of hours of instruction per subject but does not specify the number of hours to be spent on each topic within a subject. Teachers are entrusted with the freedom and flexibility to plan and organize instruction.

In Grade 4, the minimum total instructional time per year is 120 hours for mathematics and 60 hours for science and technology. On a weekly basis, the total minimum instructional time in both mathematics and science and technology is five hours. A standard lesson comprises 45 minutes, but schools may have double lessons or other arrangements.

Instructional Materials, Equipment, and Laboratories

Danish teachers often take a mixed approach to instruction, using varied materials and interdisciplinary methods. Individual teachers can select the instructional methods and materials they find suitable for their students.

Textbooks are usually used in both subjects, but teachers supplement these with materials from students' everyday lives, as well as various activities (e.g., role-playing, storylines for active learning, and graphic presentations) and hands-on work (e.g., experiments, board games, and computer games). Teachers also engage students in their outdoor surroundings to stimulate interest and wonder about the world of science and mathematics and to develop students' academic language.

Individual school boards and municipalities decide which textbooks to use. Denmark does not have a central, objective authority that assesses the quality of instructional materials. It is the responsibility of municipalities, individual school boards, or teachers to assess the quality and usability of textbooks and other teaching materials.

The Ministry of Children and Education has created a popular portal for the Danish educational system—EMU.dk. This portal gathers relevant educational materials, services, and resources available on the Internet and communicates knowledge of best practices. This portal provides links to websites with ideas for teachers in both subjects (e.g., the Material Platform).[30] Teachers also have created websites on which they describe projects and present lesson plans.[31]

Use of Technology

The use of computer technology is a priority in the Danish *Folkeskole*. During 2004–07, individual schools could apply for government grants to purchase computer equipment for third grade students, though awards were contingent upon municipal co-financing at least equal to the level of the government grants. These grants also could be used for equipment such as video projectors and interactive whiteboards. In addition, the government has funded initiatives supporting the development of new Internet-based educational materials.[32, 33] This initiative has resulted in a ratio of less than four students per computer overall and less than two third-grade students per computer in 2010.[34] The use of computers was included in 2009 in the curriculum objectives for language instruction and for other subjects as well.[35]

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Students in Grades 1–6 usually do not have specialist teachers in mathematics and science because many prospective teachers do not choose to specialize in these subjects at the primary level. For a more detailed explanation, see Teachers and Teacher Education.

Homework Policies

In Denmark, as in many other European countries, there is debate and research concerning the impact (or lack thereof) of homework. Even though the Folkeskole Act does not specify any general homework policies, many teachers assign homework.[36] However, some school boards have decided not to use homework in its traditional form; instead, students stay longer at school every day and complete their homework with the assistance of a teacher. In addition, some libraries offer assistance with homework with the help of volunteers.[37]

Teachers and Teacher Education

In 2007, Denmark reformed its teacher education program for *Folkeskole* teachers, but the program continues to be debated.[38] Whenever Danish students participate in international tests and do not achieve results that the public and politicians perceive as good enough, teachers and teacher education are often criticized.

Becoming a teacher requires four years of education in a bachelor of arts program equivalent to 240 European Credit Transfer and Accumulation System credits (ETCS).[39] An upper secondary level of education (i.e., completion of ISCED level 3A) is a prerequisite for admission to such a program.

During the first and second years of the teacher education program, students specialize in two or three subjects selected from the following compulsory areas: Danish, mathematics, science and technology, and physics and chemistry. Student teachers also study theoretical education subjects, such as psychology, didactics, and general education. Students who select Danish or mathematics as their first or second main subject can specialize in these subjects at one of two grade level spans: Grades 0–6 or 4–10.[40] Unfortunately, few prospective teachers choose to specialize in mathematics at the lower level. As a result, *Folkeskole* students often do not encounter a specialist mathematics teacher until Grade 7.[41] Lastly, during the program, prospective teachers must complete and pass a 24-week practicum, with aims and content determined by the Ministry of Children and Education; if not, the student must complete a new period.[42]

Monitoring Student Progress in Mathematics and Science

The Folkeskole Act states that schools are obligated to evaluate student learning in relation to the binding intermediate achievement goals presented in the *Common Objectives*.[43] Since 2006, there has been an overall focus on quality assurance and evaluation in primary and lower secondary school, and a large number of national initiatives on evaluation have been introduced.

In the 2007–08 school year, Denmark introduced compulsory national computer-adaptive assessment tests based on the intermediate achievement goals. These tests are pedagogical tools for teachers to use in planning the education of individual students, as well as tools for enhancing cooperation with parents. Students must complete compulsory tests in six subjects at different grades during primary and lower secondary school, though they take tests in mathematics and science less frequently than the other four subjects—Grades 3 and 6 for mathematics, and Grade 8 for science (i.e., geography, biology, and physics and chemistry). Teachers receive guidelines for the evaluation process through a website.[44] Students who have dyslexia and use computer-assisted reading programs on a regular basis are allowed to use these programs during the national assessments. Only results at the national level are published, while results for individual students, classes, and schools remain confidential.[45, 46]

In 2009, a provision was introduced requiring teachers to prepare individual learning plans for students in Grades 0–10 and to update these plans at least once a year. Student plans contain both the results of the ongoing evaluation and a course of action based on these results. Schools provide parents with a copy of the plan, with the goal of improving discussions about how parents and the school can collaborate to support student educational development.[47]

At the end of Grade 9 (or Grade 10 in the *Folkeskole*), students have seven compulsory school-leaving examinations; after Grade 10, school-leaving examinations are voluntary. Compulsory examinations for every school include the following five subjects: Danish (oral and written), mathematics (written), English (oral), and physics and chemistry (oral). The two remaining examinations are randomly selected for each school.[48] Standard rules for all examinations ensure uniformity throughout the country. The Ministry of Children and Education develops the written school-leaving examinations, and teachers conduct the oral examinations. In addition, a mandatory project assignment gives students in Grades 9 and 10 the opportunity to complete and present an interdisciplinary project.[49]

The examination in mathematics consists of two parts: a test of basic mathematical skills, and a test of problem solving. For the first test, students may use only paper and pens; for the second test, they may use a calculator and any other equipment that has been used in daily teaching. Students have four hours in total to complete both parts of the mathematics examination.[50]

Every municipal board is responsible for carrying out an annual report on the academic quality of individual schools and of the entire municipal school system. This report is a quality tool designed to ensure systematic documentation and cooperation among schools, municipalities, and the ministry.[51]

Impact and Use of TIMSS

Over the past decade, scientific literacy has been a political focus. Both the Danish government and industry have a strong interest not only in improving science skills in general, but also in increasing the number of students who complete a university education in science and choose a scientific career.

To achieve these goals, Denmark must strengthen science subjects in schools. The OECD's Programme for International Student Assessment (PISA) studies show that at the age of 15, on average, Danish students scored below the OECD average in science.[52] In 2005, a proposal was put forth arguing that the science subjects of geography and biology should be tested in Grade 9, claiming that "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 parents." [53] Mathematics and physics and chemistry are already assessed in Grades 9 and 10, but currently science is not assessed at the primary level.

State funding and political programs (e.g., A School in Movement) aim to ensure the continuous development of science instructional materials, assessment, and laboratories. In addition, new collaborative efforts aim to strengthen the professional qualifications of science teachers. Another goal is to improve the connections among the different science subjects. Schools must clarify instruction plans to ensure these connections throughout primary and lower secondary school. Furthermore, reports published in 2006 emphasize the importance of developing the theory of teaching (didactics) in mathematics and especially in science and technology.[54, 55] Denmark's past participation in TIMSS has influenced interventions which have been installed to increase interest and performance in mathematics, such as instructions for teachers and written proposals to enhance student motivation for mathematics. However, a 2009 report from the Danish Clearinghouse of Educational Research shows that, in general, the results of student tests have a limited effect on teaching directly.

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England

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Introduction

Overview of the Education System

In January 2010, there were 24,616 schools in England, with 8.1 million students enrolled. During 2010, approximately 91 percent of students in England attended publicly funded educational institutions; [1] most of the remaining 9 percent attended privately funded institutions. The Department for Education administers education at the national level. However, although a great deal of education policy is centrally determined, responsibility for day-to-day decision-making is held by the schools. At municipal and county levels, publicly funded schools have traditionally been the responsibility of a Local Authority (LA), which makes decisions about education provision in their area.

In the last few years a new model of publicly funded schools, the academy, has been introduced with responsibility devolved from the LA.

> Academies are independently managed, all-ability schools. They are set up by sponsors from business, faith or voluntary groups in partnership with the Department for Education and the LA. Together they fund the land and buildings, with the government covering the running costs. Existing schools have been offered the opportunity of converting to become an academy. [2]

At the time of the TIMSS 2011 administration, there were 407 academies in England; [3] as of February 2012, there were 1,580, and it is government policy to increase this number further.[4, 5] Academy status introduces the following organizational changes, among others: freedom from local authority control; the ability to set salaries and conditions for staff; freedom in curriculum delivery; and the ability to change the length of terms and school days.[6]

Exhibit 1 shows the structure of the three major phases of England's education system: preprimary (up to age 5), primary (ages 5–11), and secondary (ages 11–16).

Exhibit 1: Structure of the Education System in England

		Compulsory Education	
Phase	**Preprimary**	**Primary**	**Secondary**
Age	0–5	5–11	11–16
Stage	Early Years Foundation Stage: Ages 0–5	Early Years 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	Level 0: Ages 0–5	Level 1: Ages 5–11	Level 2: Ages 11–14 Level 3: Ages 14–16
Curriculum	Early learning goals: personal, social, and emotional development; communication, language, and literacy; problem solving, reasoning and numeracy; knowledge and understanding of the world; physical development; and creative development.	Core subjects: English, mathematics, science; and Foundation subjects: design and technology, information and communication technology (ICT), history, geography, art and design, music, and physical education. Religious education also is taught.	Key stage 3: Same as for primary, plus a modern foreign language and citizenship. Religious education also is taught. Key stage 4: The three core subjects plus, information and communication technology (ICT), physical education, and citizenship. Also an entitlement to choose from a variety of other subjects such as a modern foreign language, geography, history, the arts, and others.

Education becomes compulsory in the term in which a child reaches age 5. Most children in England start school just before their fifth birthday or during the academic year in which they turn five. Most primary schools include students from ages 4 or 5 to 11. Thereafter, students move on to secondary schools, most of which include students up to age 16 or 18. Compulsory schooling continues to age 16.

Publicly funded primary education is nonselective, as is most secondary education. However, some schools use forms of selection based on aptitude or ability. Schools with a particular specialty can admit up to 10 percent of students each year on the basis of their aptitude in that specialty, such as physical education, or science, among others. Selective schools, which cater to high-ability secondary students, are known as grammar schools. At the time of this writing, there were 164 grammar schools in England.

In England, the Department for Education is responsible for the development and implementation of a national curriculum for all subjects. All publicly funded schools, with the exception of academies, must follow the national curriculum during the years of compulsory schooling. This curriculum was introduced in 1988 and revised in 1999. In 2007, there were further revisions to all subjects in the national curriculum for ages 11–16. In September 2008, the government began to introduce these changes with full implementation in September 2010. A new review of the national curriculum is currently taking place and new curricula will be available in 2014.

Performance standards are described in a series of eight levels across the years of compulsory schooling. Exhibit 2 shows the expected relationship between these levels of performance and the key stages: 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); and Key Stage 3 is Years 7 to 9 of secondary school (ages 11–14). Curriculum content in each subject area is divided into attainment targets, but there are variations between the targets for each of the key stages.

Exhibit 2: Levels of Performance and Expected Attainment for Students in Key Stages 1–3

Range of Performance Levels within Which the Majority of Students are Expected to Work		Expected Performance Level Attained by the Majority of Students at the End of Each Key Stage	
Key Stage 1	Levels 1–3	At age 7	Level 2
Key Stage 2	Levels 2–5	At age 11	Level 4
Key Stage 3	Levels 3–7	At age 14	Level 5 or 6

Languages of Instruction

In all centrally funded schools in England, the official language and medium of instruction is English. In 2010, 16.0 percent of students in primary schools spoke a language other than English at home. In secondary schools, the proportion was 11.6 percent. Languages other than English predominantly spoken at home include Punjabi, Urdu, Gujarati, Hindi, and Bengali.[7] The official policy is to integrate children who are at the earliest stages of learning English into mainstream schools, providing additional language support if necessary.

Mathematics Curriculum in Primary and Lower Secondary Grades

The curricula described below were those in use when the TIMSS 2011 assessment was administered in England. The current mathematics curriculum is delivered in key stages, which are age related. This chapter describes only Key Stages 2 and 3 because those are the grades tested in TIMSS.

The current Key Stage 2 curriculum dates from 1999 (but is based upon the original curriculum introduced in 1988). The main content for mathematics at Key Stage 2 is listed below, with the attainment targets first, followed by the main content areas for each attainment target:

- Using and Applying Mathematics—Problem solving, communicating, and reasoning;
- Number and Algebra—Numbers and the number system, including counting, number patterns and sequences, integers, fractions, percentages and ratios, and decimals; mental, written, and calculator methods of calculation, including number operations and the relationships between them; solving numerical problems; and simple formulae expressed in words and symbols;
- Shape, Space, and Measures—Understanding properties of shapes, positions, movement, and measures; and
- Handling Data—Processing, representing, and interpreting data.

The curriculum gives particular emphasis to Using and Applying Mathematics, by relating the other three attainment targets to it.

At Key Stage 2, each part of the curriculum has associated level descriptors which describe the expected levels of attainment. The following are examples of descriptors from Level 4, which is the level most eleven-year-olds are expected to achieve at the end of Key Stage 2.[a] The examples describe the level of many of the students who took the TIMSS fourth grade mathematics assessment at ages 9–10. The examples are from the level descriptors for Number and Algebra, and Shape, Space and Measures:

- Number and Algebra—Students are expected to achieve the following: use their understanding of place value to multiply and divide whole numbers by 10 or 100; use a range of mental methods of computation with the four arithmetic operations (addition, subtraction, multiplication, and division) when solving number problems, including mental recall of multiplication facts up to 10 x 10 and quick derivation of corresponding division facts; use efficient written methods of addition, subtraction, short multiplication, and division; add and subtract decimals to two places and order decimals to three places; check the reasonableness of results when solving problems with or without a calculator, with reference to knowledge of the context or to the size of the numbers; recognize approximate proportions of a whole and use simple fractions and percentages to describe them; recognize and describe number patterns, and relationships including multiple, factor,

a The full set of level descriptors for mathematics, including the descriptors for Using and Applying Mathematics, and Handling Data can be found at http://www.education.gov.uk/schools/teachingandlearning/curriculum/secondary/b00199003/mathematics/ks3/attainment and square; begin to use simple formulae expressed in words; and use and interpret coordinates in the first quadrant.[8]

- Shape, Space, and Measures—Students are expected to achieve the following: make three-dimensional mathematical models by linking given faces or edges, and draw common two-dimensional shapes in different orientations on grids; reflect simple shapes across a mirror line; choose and use appropriate units and instruments, interpreting, with appropriate accuracy, numbers on a range of measuring instruments; and find perimeters of simple shapes and find areas by counting squares.[9]

In 2007 there was a review of the Key Stage 3 curriculum. In September 2008, a new curriculum was introduced to Year 7 students (beginning of Key Stage 3) at the start of the school year. The new curriculum contains four sections:

- Key Concepts—Competence, creativity, applications and implications of mathematics, and critical understanding;
- Key Processes—Representing, analyzing, interpreting and evaluating, and communicating and reflecting;
- Range and Content—Number and algebra, geometry and measures, and statistics; and
- Curriculum Opportunities—Students should be offered opportunities that are integral to their learning and enhance their engagement with concepts, processes, and content of the subject.

This new 2007 curriculum was designed with revised level descriptors, but in 2009 the government decided not to implement these descriptions. Schools therefore continue to use the level descriptors from the 1999 national curriculum. As a consequence, the names of the level descriptors do not directly match the four sections of the 2007 mathematics curriculum, although they map broadly to the content. The level descriptors address four areas: Mathematical Processes and Applications, Number and Algebra, Geometry and Measures, and Handling Data.

The following are examples from Level 5.[b] Most 14-year-olds are expected to achieve Level 5 or 6 by the end of Key Stage 3. These examples describe the performance level of many of the students who took the TIMSS eighth

b The full set of level descriptors for mathematics, including the descriptors for Mathematical Processes and Applications, and Handling Data can be found at http://www.education.gov.uk/schools/teachingandlearning/curriculum/secondary/b00199003/mathematics/ks3/attainment grade assessment. The examples are from the level descriptors for Number and Algebra, and Geometry and Measures:

- Number and Algebra—Students are expected to achieve the following: use their understanding of place value to multiply and divide whole numbers and decimals; order, add, and subtract negative numbers in context; use all four arithmetic operations (addition, subtraction, multiplication, and division) with decimals to two places; solve simple problems involving ratio and direct proportion; calculate fractional parts or percentages of quantities and measurements, using a calculator where appropriate; construct, express in symbolic form, and use simple formulae involving one or two operations; use brackets appropriately; and use and interpret coordinates in all four quadrants.[10]

- Geometry and Measures—Students are expected to achieve the following: when constructing models and drawing or using shapes, measure and draw angles to the nearest degree and use language associated with angles; know the angle sum of a triangle and that of angles at a point; identify all the symmetries of two-dimensional shapes; convert one metric unit to another; make sensible estimates of measures in relation to everyday situations; and understand and use the formula for the area of a rectangle.[11]

Science Curriculum in Primary and Lower Secondary Grades

The curricula described below were those in use when the TIMSS 2011 assessment was administered in England. The science curriculum is delivered in key stages in the same way as the mathematics curriculum.

The current Key Stage 2 curriculum dates from 1999 (but is based upon the original curriculum introduced in 1988). The main content for science at Key Stage 2 is listed below, with the attainment target, followed by the main content areas for each attainment target:

- 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, and health; green plants, including growth, nutrition, and reproduction; variation and classification; and living things in their environment, including adaptation, feeding relationships, and micro-organisms.

- Materials and their Properties—Grouping and classifying materials; physical and chemical changes in materials; and separating mixtures of materials.
- Physical Processes—Electricity; forces and motion, including types of force; light and sound, including everyday effects of light, seeing, vibration, and sound; and the Earth and beyond, including the sun, Earth, moon, and periodic changes.

The curriculum gives particular emphasis to Scientific Inquiry, by relating the other three attainment targets to it.

As in the mathematics curriculum, each part of the science curriculum at Key Stage 2 has associated expected attainment level descriptors. The following are examples from Level 4[c] and describe the level of many of the students who took the TIMSS fourth grade science assessment at ages 9–10. Specifically, the examples are for Scientific Inquiry, and Life Processes and Living Things:

- Scientific Inquiry—Students are expected to achieve the following: recognize that scientific ideas are based on evidence; decide on an appropriate approach (for example, using a fair test) in their own investigative work to answer a question; describe, or show in the way they perform a task, how to vary one factor while keeping others the same (where appropriate); make predictions (where appropriate); select information from sources provided; select suitable equipment and make a series of observations and measurements that are adequate for the task; record their observations, comparisons, and measurements using tables and bar charts; begin to plot points to form simple graphs, and use these graphs to point out and interpret patterns in their data; begin to relate their conclusions to these patterns and to scientific knowledge and understanding, and communicate them with appropriate scientific language; and suggest improvements in their work, giving reasons.[12]
- Life Processes and Living Things—Students are expected to achieve the following: demonstrate knowledge and understanding of life processes and living things drawn from the Key Stage 2 or Key Stage 3 program of study; use scientific names for some major organs of body systems (for example, the heart at Key Stage 2, and the stomach at Key Stage 3) and identify the position of these organs in the human body; identify organs (for example, stamen at Key Stage 2; and stigma, root hairs at

c The full set of level descriptors for science, including the descriptors for Materials and their Properties, and Physical Properties can be found at http://www.education.gov.uk/schools/teachingandlearning/curriculum/primary/b00199179/science-/attainment

Key Stage 3) of different plants observed; use keys based on observable external features to help identify and group living things systematically; and recognize that feeding relationships exist between plants and animals in a habitat, and describe these relationships using food chains and terms (for example, predator and prey).[13]

In 2007 there was a review of the Key Stage 3 (ages 11–14) curriculum and a new curriculum was introduced to Year 7 students (beginning of Key Stage 3) at the start of the 2008 school year. The new curriculum contains four sections:

- Key Concepts—Scientific thinking, applications and implications of science, cultural understanding, and collaboration;
- Key Processes—Practical and inquiry skills, critical understanding of evidence, and communication;
- Range and Content—Energy, electricity and forces; chemical and material behavior; organisms, behavior, and health; and the environment, Earth, and the universe; and
- Curriculum Opportunities—Students should be offered opportunities that are integral to their learning and enhance their engagement with concepts, processes, and content of the subject.

As with mathematics, the new 2007 science curriculum was designed with revised level descriptors, but the government decided not to implement these descriptions. Schools therefore continue to use the level descriptors from the 1999 national curriculum. As a consequence, the names of the level descriptors do not directly match the four sections of the 2007 science curriculum, although they map broadly to the content. The level descriptors address four areas: How Science Works; Organisms, their Behavior, and the Environment; Materials, their Properties, and the Earth; and Energy, Forces, and Space.

The following are examples from Level 5[d] and describe the performance level of many of the students who took the TIMSS eighth grade science assessment. The examples are from How Science Works, and Organisms, their Behavior, and the Environment:

- How Science Works—Students are expected to achieve the following: decide appropriate approaches to a range of tasks, including selecting sources of information and apparatus; select and use methods to obtain data systematically; recognize hazard symbols and make, and act on, simple suggestions to control obvious risks to themselves and others; use line graphs to present data, interpret numerical data, and draw

d The full set of level descriptors for science, including the descriptors for Materials, their Properties, and the Earth; and Energy, Forces, and Space can be found at http://www.education.gov.uk/schools/teachingandlearning/curriculum/secondary/b00198831/science/ks3/attainment conclusions from them; analyze findings to draw scientific conclusions that are consistent with evidence; communicate findings using scientific and mathematical conventions and terminology; and evaluate working methods to make practical suggestions for improvements.[14]

- Organisms, their Behavior, and the Environment—Students are expected to achieve the following: describe processes and phenomena related to organisms, their behavior, and the environment, drawing on abstract ideas and using appropriate terminology (e.g., the main functions of plant and animal organs and how these functions are essential); explain processes and phenomena in more than one step or using a model, such as the main stages of the life cycles of humans and flowering plants; apply and use knowledge and understanding in familiar contexts, such as organisms found in particular habitats because of differences in environmental factors; recognize that both evidence and creative thinking contribute to the development of scientific ideas, such as the classification of living things; and describe applications and implications of science, such as solving some of the health problems that arise when organ damage occurs.[15]

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Materials, Equipment, and Laboratories

There are no centrally published or mandated books for teaching mathematics or science. Materials provided by the National Strategies (a government-supported initiative which ended in 2011) for mathematics and science have influenced classroom practice and some remain available for optional use.

Very few primary schools in England have science laboratories, though almost all secondary schools have them.

Use of Technology

The use of computers is widespread in schools in England. However, while the majority of teachers have access to a computer, the number of computers available for student use varies across schools. Most secondary school students have access to computers, but their use in mathematics and science lessons varies. Secondary schools also have Internet access and technical support. Primary schools are equally likely to have student access to computers, though, being smaller, these schools typically have fewer computers than secondary schools. The majority of computers in primary school have Internet access, though primary schools are less likely to have technical support on site. A large number of schools, at both primary and secondary levels, also have interactive whiteboards in the classroom.

In the current mathematics national curriculum, in use at the time of TIMSS 2011, calculator use is included at both primary and secondary levels.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

The majority of students at Key Stage 2 (ages 7–11) are taught by a general classroom teacher. Most students do not encounter subject specialists until they enter secondary school at the age of eleven. At Key Stage 3 (ages 11–14), each subject is usually taught by a subject specialist (or a team of specialist teachers).

Homework Policies

There are no official policies on mathematics and science homework at either Key Stage 2 or Key Stage 3. The recommendations for homework in the primary phase are as follows:

- Years 1 and 2 (ages 5–7)—1 hour per week (reading, spelling, other literacy work, and number work);
- Years 3 and 4 (ages 7–9)—1.5 hours per week (literacy and numeracy work, and occasional assignments in other subjects); and
- Years 5 and 6 (ages 9–11)—30 minutes per day (regular weekly schedule with continued emphasis on literacy and numeracy, but also ranging widely over the curriculum).[16]

The recommendations for homework for all subjects at Key Stage 3 are as follows:

- Years 7 and 8 (ages 11–13)—45 to 90 minutes per day in total, across all subjects; and
- Year 9 (ages 13–14)—1 to 2 hours per day total, across all subjects.[17]

Teachers and Teacher Education

Teacher Education Specific to Mathematics and Science

In January 2010 there were 448,000 full-time teachers in schools in England.[18] Teaching is an all-graduate profession into which there are two main routes: concurrent and consecutive. For each route, prospective teachers must pass five or more subjects with a grade of C or higher in their General Certificate of Secondary Education examinations (GCSEs), including English and mathematics, and pass two or more Advanced Level examinations (A-Levels) or their equivalent prior to acceptance into a teacher education program. Those who intend to teach students ages 3–11 also must have achieved a grade C or above in a science subject. Students most commonly take GCSEs at age 16 and A-Levels at age 18.

The concurrent route into teaching involves prospective teachers undertaking a three- or four-year degree that combines the study of one or more academic subjects with professional training in aspects of education (a Bachelor of Education or Bachelor of Arts, with a recommendation for qualified teacher status). Alternatively, the consecutive route requires completion of a three-year bachelor's degree, followed by a one-year Postgraduate Certificate in Education (PGCE). The consecutive route also includes School Centered Initial Teacher Training (SCITT) programs, which are designed and delivered by groups of neighboring schools and colleges. The majority of teachers entering secondary schools have a relevant degree and a PGCE.

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 attributes, professional knowledge and understanding, and professional skills.

Student teachers register 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, often coupled with a curriculum specialization, while secondary teachers are subject specialists.

During the early part of their teaching careers, mentors support newly qualified teachers within their schools and qualified teacher status is confirmed on satisfactory completion of three school terms of teaching (the induction year). This aims to provide a bridge between initial teacher education and effective professional practice.

Requirements for Ongoing Professional Development

There are a variety of opportunities for continuing professional development for teachers, ranging from in-school development opportunities and short, one-day courses to higher degrees, studied part-time over several years. Individual local authorities, higher education institutions, or specialist companies or consultants may provide professional development. Most publicly funded schools allocate five days in each academic year to professional development, deciding which specific days and focuses best suit their needs. Academies are under no obligation to provide the same number of days, which are set at the head of school's discretion.

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 mathematics and science teacher professional development.[19, 20]

Monitoring Student Progress in Mathematics and Science

Throughout primary and secondary education, teachers undertake continuous formative assessment of their students' attainment. At Key Stage 1, for reading, writing, and mathematics, teachers must administer a nationally produced written test and a set of classroom tasks. The test and tasks are set by an external agency and scored by the class teacher. The outcomes inform teachers' assessments in these domains and the teacher assessment results for seven-year-olds are published at a national summary level.

At Key Stage 2, external tests are used to assess mathematics and English. In mathematics, two written tests are taken—one without the use of a calculator and one with a calculator—as well as a test of mental mathematics. New tests are developed each year. At age eleven, the mathematic tests address Levels 3 to 5 of the national curriculum. Students are awarded a national curriculum level according to the number of marks (points) scored. The English and mathematics tests for children age eleven are scored externally by trained evaluators, and the results are returned to schools. The test results for Key Stage 2 English and mathematics are published nationally on a school-by-school basis. In order to monitor national standards in Key Stage 2 science, an externally marked science test, comprising two written papers, is administered to a representative sample of students. The Department for Education reports the proportion of students who attained Level 4 or above nationally in the science monitoring test. There is no reporting of this test at the school or local level. Teacher assessment results for English, mathematics, and science at Key Stage 2 (age 11) also are reported at a national summary level. Until 2008, compulsory national curriculum tests in English, mathematics, and science took place at the end of Key Stage 3 (age 14). These were externally set and scored. In 2008, these national curriculum tests were abolished, while teacher assessment in English, mathematics, and science remained statutory. The teacher assessment results at Key Stage 3 are reported at a national summary level.

At age 16, secondary school students participate in a variety of vocational and non-vocational examinations, including the most common qualification at age 16, GCSEs. Students take A-Level examinations in three or four subjects at age 18, after two years of post-compulsory education. Examination results are published for individual schools for students ages 16 and 18.

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 to support teacher assessment are available in Years 3, 4, and 5 (Key Stage 2) and Years 7, 8, and 9 (Key Stage 3) for mathematics, and in Year 9 (end of Key Stage 3) for science.

Impact and Use of TIMSS

England has participated in all previous cycles of TIMSS at both fourth and eighth grades (and at eighth grade in 1999, which assessed eighth grade students only).

The profile of international surveys has increased in England in recent years, and reference to TIMSS and other international surveys has been made in key policy documents such as *The Importance of Teaching—The Schools White Paper 2010*.[21] Despite the attention paid to results, it has remained challenging to recruit schools in England for participation in international surveys such as TIMSS. These challenges have prompted the government to change policy; the Education Act 2011 provides legislation that now can require publicly funded schools in England to participate in future international surveys when drawn in the sample. In addition, the Department for Education has used the TIMSS 2007 results, with additional analysis, to inform the curriculum review which began in 2011.

In England, each school participating in TIMSS receives scores and attitudinal feedback for its students, and participating schools are sent summaries of the national report. As a consequence, the study has the potential to impact teaching and learning at the school level for participants.

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Finland

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Introduction

Overview of the Education System

In Finland, education is considered a fundamental right of all citizens, and the main objective of Finnish education policy is to offer all citizens equal opportunities to receive education, regardless of age, nationality, place of residence, financial situation, or mother tongue.[1]

The Finnish government determines general objectives of basic education and the allocation of instructional time among the different subjects. The National Board of Education, which reports to the Ministry of Education and Culture, decides objectives and contents of instruction and records them in the national core curriculum. Municipalities prepare their local curricula based on this national core curriculum. During the 1990s, decentralization of decision-making on curricular issues was a major emphasis. More recently, educational policy is working toward accentuating core competencies and defining standards of proficiency levels in core subject areas.

The majority of students attend publicly funded schools. Municipalities or federations of municipalities maintain most primary and upper-secondary level institutions. Private schools receive the same level of public funding as publicly funded schools.

Municipalities have significant freedom in organizing schooling along the general guidelines provided by the ministry and the national board. In addition, schools (and teachers) have autonomy regarding pedagogical practices and methods of student assessment within the guidelines of the national curriculum.

Before compulsory education begins, a child may voluntarily participate in one year of preprimary education, which municipalities are obliged to provide. Compulsory education usually starts the year in which a child turns seven. The basic education syllabus spans nine years, which nearly all children complete by attending comprehensive school. Basic education is free of charge for all students and includes textbooks and other materials, a free daily meal, and school health care and other welfare services.

The upper-secondary level comprises general and vocational education. Both have a three-year syllabus, and education is mostly free, though students must pay for materials. General upper-secondary school ends in a matriculation examination that determines eligibility for higher education studies in both polytechnics and universities. The vocational upper-secondary qualification examination gives general eligibility for all higher education.

From 1996 to 2002 an extensive program—LUMA—was implemented to develop mathematics and science education in Finland. LUMA comprised 78 municipalities and 10 training schools, totaling 270 educational institutions and their teachers.[2]

The Ministry of Education and the Finnish National Board of Education supported the program with €34 million in development funds to promote many development activities, stimulating students in the LUMA schools to select more optional courses in mathematics and improving motivation among teachers and students through the integration of mathematics, science, and information technology. Collaboration between different school levels became more extensive and cooperation between teachers increased. Altogether, 11,000 teachers participated in professional development teacher training courses and earned roughly 128,000 European Credit Transfer System (ECTS) credits. LUMA was, therefore, a significant investment in Finnish mathematics and science education and the program indisputably created new educational opportunities and stimulated new enthusiasm in teachers' work. However, the long-term impact of the program has yet to be established.

Languages of Instruction

Finland has two official languages—Finnish and Swedish. Finnish is spoken by 93 percent of the country's 5.4 million inhabitants. The other official language, Swedish is spoken by approximately 6 percent of the population, most of whom can also speak Finnish. The constitution of Finland stipulates that the two national languages are equal throughout the country with respect to dealing with authorities and schooling.

Sami is a minority language that is spoken by approximately 2,000 people (less than 0.1% of the Finnish population) living in the north of Finland. The Sami-speaking population has the right to use the Sami language when dealing with the authorities. Other language minorities include Finnish sign language users, the Roma, Russian-speakers, and more recent immigrant groups. The

Sami, as an indigenous people, have the right to maintain and develop their own language and culture, as do the Roma and sign language users.[3]

Finnish and Swedish are languages of instruction for all educational levels and school subjects. Usually either Finnish or Swedish is the language of instruction, but some upper-secondary vocational institutions and universities are bilingual. Sami is the language of instruction in some basic education, upper-secondary general, and vocational institutions in the Sami-speaking areas.[4]

Mathematics Curriculum in Primary and Lower Secondary Grades

Finland recognizes the significant influences of mathematics education on students' intellectual growth and their ability to advance purposeful activity and social interaction. According to the National Core Curriculum for Basic Education, the purpose of mathematics instruction is to offer opportunities to develop mathematical thinking and learn mathematical concepts and problem-solving methods. The goal of instruction is to develop creative and precise thinking and guide the student in finding, formulating, and solving problems.[5]

Mathematics instruction progresses systematically to create a lasting foundation for the assimilation of mathematical concepts and structures. The nature of the discipline brings together student experiences and systems of thought with the abstract system of mathematics. Problems that arise in everyday situations, and that can be resolved with the aid of mathematical thinking or operations, are examined. Information and communication technologies are used to support student learning.

In the first and second grades, mathematics instruction focuses on mathematical thinking as well as concentration, listening, and communication skills, while providing a basis for the formulation of mathematical concepts and structures. During these first two years the core contents are as follows:

- Numbers and Calculations—Number and number symbols; properties of numbers; comparison, classification, ordering, and use of manipulatives to break down and assemble numbers; the decimal system; addition and subtraction, and using natural numbers; multiplication and basic multiplication tables; division using concrete tools; methods of calculating, including blocks and decimal tools, number lines, mental calculation, and pencil and paper; and introducing basic concepts of fractions using manipulatives.

- Algebra—Identifying patterns, ratios, and correlations pictorially; and simple number sequences.
- Geometry—Observing and describing spatial relationships; observing, describing, and naming geometric shapes in the environment; recognizing, explaining, and naming two- and three-dimensional figures; basic geometric concepts such as point, line segment, line, half-line, and angle; making, drawing, and tracing two-dimensional figures and recognizing and constructing three-dimensional figures; and simple reflections and dilations.
- Measurement—Principles of measurement; length, mass, area, volume, time, and price; use of measuring devices; comparisons of units of measurement; and analysis of measurement results.
- Data Processing and Statistics—Looking for, collecting, and storing data; and reading simple tables and diagrams and presenting collected data as a graph.

The core objectives of mathematics instruction in the third through fifth grades are to develop mathematical thinking, introduce mathematical modeling, strengthen basic calculation skills, reinforce the concept of number, and provide a basis for assimilating the concepts and structures of mathematics. During these years the core contents of instruction are as follows:

- Numbers and Calculations—Developing the concept of the decimal system, introduction to the base-60 system, and telling time; classification and organization of numbers; multiplication; ratios, division into parts, and divisibility; algorithms and mental calculation; the concept of a fraction and conversion of fractions; the concept of decimal fractions; the relationship between fractions, decimal fractions, and percentages; addition, subtraction, and multiplication of fractions and decimal fractions; division by natural numbers; evaluating, checking, and rounding the results of calculations; use of parentheses; and the concept of negative whole numbers.
- Algebra—The concept of the algebraic expression; the interpretation and writing of number sequences regularities, ratios, and correlations; and using deduction to solve simple linear equations and inequalities.
- Geometry—Dilations; similarity and scale; reflections across a line and around a point and symmetry; congruence; the circle and its parts; parallel and perpendicular lines; measurement and classification of angles; classification of different types of polygons; circumference,

perimeter, and area; geometric properties of two- and three-dimensional figures; reinforcement of the principle of measurement; use, comparison, and conversion of units of measurement; evaluation of measurement results; and revision of measurements.

- Data Processing, Statistics, and Probability—Searching for, gathering, storing, and presenting data; the Cartesian coordinate system; reading simple tables and diagrams; concept and computation of the arithmetic mean; classification and organization of data; introduction to the concepts of mode and median; and experiences with classical and statistical probability.

The core objectives of mathematics instruction in the sixth through ninth grades are to deepen the understanding of mathematical concepts and further develop modeling skills with an emphasis on everyday mathematical problems, to provide experiences that encourage students to think mathematically, and to develop the ability to express mathematical ideas precisely. The core contents of instruction during these four years are as follows:

- Thinking Skills and Methods—Processes that demand logical thinking, such as classification, comparison, organization, measurement, constructing, modeling, and articulating rules and correlations; the interpretation and use of concepts to make comparisons and correlations; the interpretation and production of mathematical texts; introduction to proof, including justified conjectures and experiments, systematic trial-and-error method, demonstrating incorrectness, and direct proof; solving combinatorial problems; use of tools and drawings to investigate problems; and the history of mathematics.

- Numbers and Calculations—Strengthening basic calculation skills; natural numbers, whole numbers, rational numbers, and real numbers; negative numbers, absolute values, and reciprocals; time calculations and intervals; prime numbers, division of numbers into prime factors, and rules for divisibility; reduction of fractions, conversion of fractions and decimal fractions as common fractions; multiplication and division with fractions and decimal fractions; simplification of expressions; ratio and proportion; strengthening the concept of percentage and calculating percentages; rounding and estimation; using a calculator; powers using whole-number exponents; and the concept of root and square-root calculations.

- Algebra—Expressions and their simplification, exponential expressions and their simplification, and the concept of polynomials; addition, subtraction, and multiplication of polynomials; concept of variables; calculating the value of an expression; equation, inequality, domain, and range; solving a first-degree equation and an incomplete quadratic equation; proportionality; simultaneous equations and their solution algebraically and graphically, and study and formulation of number sequences.

- Functions—Observing correlation and presentation by means of variables; concept of functions; presenting a set of coordinates in a coordinate system; interpreting simple functions and drawing their graphs in a coordinate system; investigating the graph of a function, including the function's root, largest and smallest values, increasing and decreasing functions; linear functions; and direct and inverse proportionality.
- Geometry—Relationships between angles; concepts related to triangles and quadrilaterals; regular polygons; the circle and related concepts; calculating the perimeter and area of plane figures; naming and classifying three-dimensional figures; calculating the volume and surface area of a three-dimensional figure; similarity and congruence; geometric constructions; depictions of congruence, including reflections, rotation, and transformation; the Pythagorean theorem; relationships between triangles and circles; and trigonometry and solving right triangles.
- Probability and Statistics—Concept of probability; frequency and relative frequency; determining average, mode, and median; concept of dispersion; interpretation of graphs; and gathering and adapting information, and presentation in a usable form.

Science Curriculum in Primary and Lower Secondary Grades

In the first through fourth grades, Environmental and Natural Studies is taught as an integrated subject encompassing the fields of biology, geography, physics, chemistry, and health education. Instruction in the subject group includes a focus on sustainable development. The objective of instruction is that students come to know and understand nature and the man-made environment, themselves and other people, human diversity, and health and disease.

Instruction in environmental and natural studies relies on an investigative, problem-centered approach in which the starting points include students' existing knowledge, skills, and experiences, and things, phenomena, and events connected to their environment and the students themselves. With the aid of experiential instruction, the students develop a positive relationship with nature and the environment. During these first four years, the core contents of studies in environmental and natural studies are as follows: [6]

- Organisms and Living Environments—The basic features of living and non-living things; various living environments and the adaptation of organisms to them; common species of plants, fungi, and animals in the students' immediate environment; nature through the seasons; life stages of flora and fauna; and sources and production of food.
- Immediate Environment, Home Region, and the Globe as Human Living Environments—The immediate environment; times of the day and the seasons; maps and main features of the terrain; home region and province: natural conditions, landscapes, man-made environment, and human activity; and Finland, the Nordic countries, other nearby regions, and the globe as places where people live.
- Natural Phenomena—Phenomena related to sound and light; protection of hearing and eyesight; phenomena related to heat; heat sources; functioning principles of simple devices; the strength of various structures; and magnetic and electrical phenomena.
- Substances Around Us—Substances and materials that are part of everyday life; recycling and conservation; properties of air; combustion and fire safety; properties and changes of state of water; utilization of water; and the water cycle.
- The Individual and Health—The human body and the stages of human growth and development in general terms; everyday health habits and caring for one's health; being ill and common children's diseases; emergency preparedness and simple first-aid measures; and the importance of family, friendship, interaction, and the recognition of one's own feelings to one's well-being and mental health.
- Safety—Preventing bullying and violence, respecting physical inviolability, safety in school, behavior in traffic and avoiding dangerous situations, and accidents at home and in leisure time; and agreements and rules, good manners and taking other people into account, using money, and respecting the property of others.

From the fifth through ninth grade, science is taught as separate subjects, including biology, geography, physics, chemistry, and health. Instruction in each subject is described below for Grades 7–9. [7]

In biology, life and its phenomena and prerequisites come under investigation. Instruction develops students' knowledge of nature and guides understanding of basic natural phenomena. The objective is that students also are introduced to evolution, the fundamentals of ecology, and the structure and vital functions of human beings. The core contents in biology instruction for Grades 7–9 are as follows:

- Nature and Ecosystems—Identification of major species of plants, fungi, and animals in students' home regions, and guided collection of plants; the ecosystem and its structure and operation, distinctive features of forest and aquatic ecosystems, and independent research on one ecosystem; introduction to forestry, crop husbandry, and biodiversity.
- Life and Evolution—Structure and activity of the cell; emergence, development, and organization of the population; biological and cultural evolution of human beings, and distinctive features of the human species; and potential of biotechnology, including related ethical questions.
- The Human Being—Structure and major vital functions of the human body; human sexuality and reproduction; and importance of genotype and the environment in the development of human characteristics.
- The Common Environment—Ecologically-sustainable development and objectives of environmental protection; and investigation of the conditions of, and changes in, one's living environment, examination of measures to improve the condition of one's immediate environment, and consideration of ways to improve one's environmental behavior.

In geography instruction, the world and its various regions and regional phenomena come under investigation. The objective of geography instruction is to develop students' ability to examine natural, man-made, and social environments, and the interaction between people and the environment, from the local to the global level. The core contents in geography instruction for Grades 7–9 are as follows:

- Earth—Humanity's home planet, including identifying the physical-geographic and human-geographic map views of the world and analyzing the world regionally; major internal and external events of the Earth; and the continents, including comparison of natural conditions, human activity, and cultural features.
- Europe—Basic features of Europe's geography, natural conditions, landscape, and human activity; interaction of those features in different

regions of Europe; and geographic study of Europe as a part of the world and the future of Europe.

- Finland in the World—Finland's geography and landscape; interaction of nature and human activity in different regions of Finland, the man-made environment and traditional landscapes; population of Finland and its minority cultures; opportunities for influence in planning and developing one's environment; Finland as a part of the world; and small-scale research into one's immediate environment or home municipality, including natural, man-made, and social environments.

- The Common Environment—Environmental and developmental questions, locally and globally; consideration of possible solutions to problems; environmental questions in the Baltic region; and human beings as consumers of natural resources.

The core objective of physics instruction is to broaden students' knowledge and conception of the nature of physics, and to strengthen skills in the experimental acquisition of information. The starting points for physics instruction are prior student knowledge, skills, and experiences, and student observations and investigations of objects, substances, and phenomena in nature. The core contents in physics instruction for Grades 7–9 are as follows:

- Motion and Force—Interactions and the corresponding forces, including the phenomena of motion and equilibrium that arise from those interactions and occurrence of those phenomena in nature; motion and models of uniform and uniformly accelerating motion; work done by a force; and mechanical energy and power.

- Vibrations and Wave Motion—Various basic phenomena of vibrations and wave motion; production, detection, observation, and reflection and refraction of wave motion; related properties, quantities, and laws of waves; importance and applications of sound and light; and functioning principles of optical instruments.

- Heat—Phenomena associated with heating and cooling of objects and substances; description of those phenomena with appropriate concepts and laws; importance and applications of thermal phenomena; and conservation and degradation of energy, and heat as a form of energy.

- Electricity—Electrical and magnetic forces between objects; direct current circuits; basic phenomena of electrical circuits; safe application of those phenomena in everyday life and technology; electromagnetic induction and its use in energy transmission; and use of electricity at home.

- Natural Structures—Natural structures and proportions; interactions that keep structural components together; binding and release of energy in processes occurring between components; radioactive decay; fission and fusion; ionizing radiation and its effect on animate nature; and protection from radiation.

The objectives of chemistry instruction are to expand students' knowledge of chemistry and the nature of chemical information and to guide scientific thinking, knowledge acquisition, and application of that knowledge in different life situations. Instruction relies on an experimental approach that starts with the observation and investigation of substances and phenomena associated with the living environment. The core contents in chemistry instruction for Grades 7–9 are as follows:

- Air and Water—Atmospheric substances and their importance to the individual and the equilibrium of nature; water and its properties, such as acidity and alkalinity; flammability of substances; combustion reaction and its description using the symbolic language of chemistry; and properties of the products of combustion and their effects on the environment.
- Raw Material and Products—Key elements and compounds found in the Earth's crust and their properties, and the manufacture, use, efficiency, and recyclability of products; electrochemical phenomena, the electrochemical cell and electrolysis, and their applications; symbolic designation, classification, and distinction of elements and compounds; comparison of reaction rates; interpretation of reaction equations and balancing of simple reaction equations; and explanation of properties and structures of elements and compounds with the aid of an atomic model or the periodic table.
- Living Nature and Society—Photosynthesis and combustion; energy sources; oxidation reactions and reaction products of organic compounds such as alcohols and carboxylic acids, and properties and uses of these products; hydrocarbons, proteins, and lipids, and their composition and importance as nutritional substances and industrial raw materials; detergents and cosmetic materials; and textiles.

Health education is based on a multidisciplinary foundation of knowledge. The intent of health instruction is to promote students' competence regarding health, well-being, and safety. Instruction develops cognitive, social, functional and ethical capabilities, and capabilities for regulating emotions. The starting point for instruction is an understanding of health as a physical, psychological, and social phenomenon. The core contents in health education during Grades 7–9 are as follows:

- Growth and Development—Birth, death, and the different stages of life; physical growth and development, including daily rhythm, sleep, rest and stress, health-enhancing physical activity, and nutrition and health; psychological growth and development, including self-knowledge and self-esteem; family and social relationships; mental health and its changes, and the balance of mind and body; social growth and development, including individuality and diversity, individual obligations and responsibilities within the community, tolerance, and caring; needs and special features in the development of young people and development of sexuality; and taking care of one's health.
- Healthy Choices in Daily Living—Nutritional needs and problems in different situations; common allergies and special diets; smoking, alcohol, drug abuse, and the use of other intoxicating substances; pleasure, dependency, and making choices; solving conflicts and talking about issues; sexual health, including human relations, sexuality, behavior, and related values and norms; common infectious diseases and illnesses, recognition of symptoms, being ill, and self-care; and traffic safety and behavior in traffic, dangerous situations, and accidents and first aid.
- Resources and Coping Skills—Health, work skills, and functional abilities as personal resources; emotions and their expression, social support and safety nets, and interaction skills; changes related to development and life span; and crises and coping with them.
- Health, Society, and Culture—National diseases; environment and health, on-the-job welfare, culture, and health; main healthcare and welfare services, careers in non-governmental organizations; and rights of children and young people and legislation regarding limitations on activities and consequences.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Materials, Equipment, and Laboratories

In Finland, the main materials for teaching mathematics and science are textbooks published by commercial publishers. These textbooks are not subject to official approval but they must comply with national curriculum guidelines. There are two to three widely used textbook series both for the primary level (Grade 4) and for the lower-secondary level (Grade 8). In addition to the student textbook, the mathematics series usually include teacher's guides, supplementary materials, assessment materials, and some manipulatives for the primary level. Publishers may also offer instructional materials on their websites.

Schools and teachers are free to choose any textbook series they find suitable. For practical reasons, teachers in the same school usually use the same textbook.

When studying science, it is crucial that students have an opportunity to observe and analyze; therefore, being able to work and move about safely is essential. The number of teaching facilities specially equipped for science instruction is based on the number of science lesson hours per week: one room is needed for up to 27 lesson hours. In addition, appropriate laboratory equipment should be available for teachers and students (e.g., draught, germination, heat cupboards, sinks, faucets, and hot plates).[8]

Use of Technology

The National Core Curriculum includes six cross-curricular themes, and their objectives and contents are incorporated into a range of subjects. Integrating education and instruction, the cross-curricular themes also respond to topical educational challenges. One cross-curricular theme, Technology and the Individual, has the goal of helping students understand an individual's relationship to technology and recognize the importance of technology in daily life.[9]

There are 5.5 students per computer in basic education, on average, and in primary schools nearly 80 percent of schools have fewer than ten students per computer.[10]

Technology use is becoming more common in mathematics and science instruction. In spring 2006, 61 percent of Finnish science teachers and 48 percent of mathematics teachers had used information and communication technology (ICT) in their eighth-grade teaching.[11] However, only 9 percent of mathematics teachers and 13 percent of science teachers reported using ICT regularly in their teaching.

In science instruction, ICT is used for measurements, reporting results, and searching and processing knowledge. Various measurement equipment and mobile devices are used both in the classroom and in outdoor studies. In mathematics instruction learning games are available (e.g., *Ekapeli-Matikka*) for training in basic mathematics skills and concepts at the beginning of primary school.[12] If and when these are used, such games only supplement the more traditional methods and materials.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

In Finnish basic education, there are specialist teachers for mathematics and science in Grades 7–9 (lower-secondary level of the comprehensive school). Classroom teachers teach mathematics and environmental and natural studies mainly in Grades 1–6 (primary level). Only about 10 percent of classroom teachers have specialized in mathematics during their teacher training programs, and these teachers also are qualified to teach in Grades 7–9.

Homework Policies

Finland has no official homework policy. In practice, mathematics teachers assign homework from student textbooks.

Teachers and Teacher Education

Teacher Education Specific to Mathematics and Science

In Finland, a master's degree is a prerequisite for teacher qualification. Eight universities provide teacher education for both general classroom teachers as well as specialist teachers. The general content and structure of teacher education programs, as well as the master's degree program requirements, are regulated by government regulations.[13] Universities have independence regarding the specific content of teacher education programs.

Classroom teachers are responsible for teaching students in Grades 1–6. Prospective classroom teachers major in education and normally complete their master's degree programs within five years. The extent of obligatory study in mathematics education is about seven credits (2% of the master's degree). In chemistry and physics education, the amount of compulsory study is three credits in each subject. Besides the compulsory courses, prospective classroom teachers may complete an elective minor subject (60 credits), which qualifies them to teach this particular subject as a specialist teacher in Grades 7–9. On average, about 10 percent of prospective teachers select mathematics as their minor. Altogether, 20 credits are allocated to guided-teaching practice during pedagogical studies (60 credits).[14]

Specialist teacher education is provided in cooperation with different university departments and faculties. Subject-specific courses are taken in the department of the particular subject (e.g., mathematics) and the department of teacher education provides pedagogical courses. Teaching practica included in pedagogical studies are organized at university teacher training schools and at so-called affiliated schools. In general, specialist teacher education lasts five to six years.

Prospective specialist teachers in mathematics and science choose a major (160 credits) and a minor (60 credits) within the subjects they intend to teach. Typical combinations are mathematics, physics and mathematics, chemistry and mathematics, computer science and physics, chemistry, and biology. Specialist teachers are required to take 60 credits of pedagogical studies, one-third of which consist of guided-teaching practice (20 credits). Prospective specialist teachers complete their master's thesis (40 credits) in their subject-area major.

Requirements for Ongoing Professional Development

Teachers' collective agreements on working conditions regulate teachers' obligation to participate in professional development for three days during each school year.[15] Teacher employers, such as municipalities, are typically responsible for organizing and funding their staff's professional development, including in-service training. Regional authorities and the National Board of Education also provide in-service training. The content and focus of in-service training vary between municipalities and regional authorities.

The National Board of Education also is responsible for funding, monitoring, and promoting teacher professional development, usually focusing on topics relevant to national education policy. Education providers can apply for funding from the National Board of Education on a yearly basis.[16]

In recent years, in-service teacher education participation has decreased, and the Ministry of Education and Culture has started to emphasize teacher professional development by doubling funding for this purpose and launching a new development program. The development program is organized and funded through regional authorities and the National Board of Education.[17]

Monitoring Student Progress in Mathematics and Science

The Finnish National Board of Education is responsible for developing education, and thus conducts national assessments of learning outcomes. National assessments are sample-based and focus on the central content of the national curriculum, mainly at the end of basic education. Since 1998 the Finnish National Board of Education has implemented a national assessment of mathematics four times for Grade 9 (in 1998, 2002, 2004, and 2011) and twice for Grade 6 (in 2000 and 2007). During this same period, two national assessments of natural sciences have been implemented for Grade 9 (in 1998 and 2011). These national assessments provide schools and teachers with regular updates about the knowledge and skills of their students in relation to other schools and national objectives of instruction.[18]

Teachers are responsible for student assessment in the classroom and may decide on the methods of assessment, which typically include teacher-made examinations, examinations based on the textbook, and continuous observation of student progress.

Impact and Use of TIMSS

Finland participated in TIMSS 1999 but not TIMSS 2003 or TIMSS 2007. The results of TIMSS 1999 were released when the development process for the new core curriculum for basic education was just beginning. Between 2000 and 2003, TIMSS mathematics and science researchers actively participated in several national meetings and symposia organized by the Finnish National Board of Education. Concurrently, several articles and reports were published exploring the strengths and weaknesses of the Finnish education system in the light of the TIMSS results.[19]

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Georgia

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Introduction

Overview of the Education System

In 2005, the Parliament of Georgia adopted the Law on General Education, which defines the general education system in Georgia. The Ministry of Education and Sciences of Georgia (MoES), a main governmental body, together with its centers (legal entities of public law) forms educational objectives and short- and long-term strategic plans, establishes national standards, creates and approves national curricula, and determines criteria for textbook evaluation.

During the last decade, the Georgian education system has undergone large-scale, simultaneous changes that included decentralization of management, new national curricula and school textbook development, and changes to a per capita financing system, teacher professional development programs, and standardized student assessments. Decentralization of education management has led to the formation of twelve regional resource centers responsible for monitoring and overseeing the general education system in their assigned regions of the country.

During these reforms, the government policy on education has aimed at improving oversight and funding mechanisms for education, granting autonomy to educational institutions, and improving learning and labor market outcomes of educational programs. This includes establishing a quality assurance system at all education levels in addition to improving local school infrastructure and management.

Georgia's general education system is divided into three levels: primary education, covering Grades 1–6; basic (lower secondary) education, covering Grades 7–9; and upper secondary education, covering Grades 10–12.[1] Article 6 (VI) of the Law on General Education states that students enter primary school at the age of five unless exceptions are made MoES. Under the current Constitution, education is compulsory through Grade 9. Completion of three-year upper secondary education provides access to higher education after passing a school-leaving and competitive university entrance examination.

The Georgian education system encompasses both public and private schools. In the 2010–11 school year, there were 2,430 schools in the country, of which 2,130 were public and 300 were private. The same year, 595,400 students were enrolled in general education schools in Georgia (542,400 in public and 53,000 in private).[2] There are a total of 71,843 teachers in all levels of education in Georgia in all school subjects, of which 46,997 are primary school teachers (Grades 1–6).[3]

Languages of Instruction

The official language of the Republic of Georgia is Georgian, a member of the South Caucasian (Kartvelian) family of languages which uses a unique alphabet known since the fifth century A.D. According to the constitution, the Abkhazian language also is recognized as an official language in the territory of Abkhazia (currently under Russian occupation).

Georgia has been a multiethnic country for centuries, hosting more than 26 ethnic groups.[4] Georgians are the country's predominant ethnic group (83.8%) while other major ethnic groups include Azeris, Armenians, Russians, Abkhazians, Ossetians, Greeks, Jews, and Kurds.[5] Although Georgian is the primary language of instruction, Article 4 (IV) of the Law on General Education states that ethnic minorities also have right to receive instruction in their native languages in secondary schools.[6]

MoES initiates various civic integration programs for ethnic minorities. Particularly noteworthy is the Georgian Language for Future Success program, which promotes Georgian language teaching in ethnic minority districts. In 2011, MoES sent 140 volunteers to regions populated with ethnic minorities to help teach Georgian to local school teachers.[7] Another program, Teach Georgian as a Second Language, involves sending qualified teachers of Georgian language to the minority-populated regions to teach Georgian.

Georgia always has enjoyed a strong literacy tradition. According to the UNESCO Institute of Statistics, adult literacy (i.e., ages 15 and older) rates in Georgia are 99.7 percent among women and 99.8 among men, and youth literacy (specifically, ages 15–24) rates are 99.9 and 99.8 percent among women and men, respectively.[8] In 2009, Georgia's net enrollment rate in primary education for both genders was 100 percent, as was the transition rate from primary to secondary education.[9]

Mathematics Curriculum in Primary and Lower Secondary Grades

Mathematics always has been regarded as one of the most important subjects; consequently, it has enjoyed significant attention from both policymakers and schools. This attention has been reflected in different aspects of national policy, including development of Olympiads in 2008, which encourage talented students to learn mathematics and science.

The introduction to the national curriculum states that its main purpose is to support every constituency involved in general education—including teachers, students, parents, textbook authors, and educational managers—to plan and implement the learning process effectively.[10] The national curriculum describes the requirements that must be fulfilled by every student for successful completion of each grade and presents them in the form of outcomes and relevant indicators.

Since the adoption of the Law of General Education in 2005, the curriculum has been changed several times, with the most recent revision being effective for the period 2011–16. For the period of the TIMSS 2011 administration, the curriculum (effective for the 2010–11 school year) stated the following general aims to be achieved in mathematics teaching and learning:

- Develop students' thinking abilities;
- Develop abilities for deductive and inductive reasoning, supporting opinions with relevant arguments, and analyzing phenomena, facts, and events;
- Master mathematics as a universal language of science and as a description of the universe;
- Understand the role of mathematics as a component of human culture;
- Prepare for subsequent a professional career; and
- Acquire the mathematical knowledge necessary for completing daily tasks, and develop skills needed for practical application of this knowledge.

Mathematical competence includes mastering mathematical notions and procedures, as well as acquiring skills for applying them when solving problems, and developing communication abilities essential for obtaining and providing information through mathematical language and methods. Therefore, mathematics education aims to develop reasoning, communication, application and modeling, and problem-solving skills as well as to form positive attitudes towards the subject. To reflect this, the national curriculum in mathematics is conventionally subdivided into four domains: Numbers and Operations; Geometry and Spatial Reasoning; Data Analysis, Probability, and Statistics; and Algebra. Although these domains are tightly interrelated and cover the knowledge and skills to be acquired at school, this division should not be confused with the division of courses. Domains merely help to outline the range of materials to be taught and highlight what should be given special consideration at different stages of the learning process.

The four domains encompass the following detailed content:

- Numbers and Operations—Numbers, their uses, and ways to present them; operations on numbers and numerical relationships; estimation and the approximation of quantities; and quantities, measurement units, and other uses of numbers.
- Geometry and Spatial Reasoning—Geometric objects, their properties, relationships, and constructions; measures and methods of measurement; 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, and functions and their uses; elements of discrete mathematics and their uses; algorithms and recursions; and algebraic operations and their properties.

Apart from more general aims, the curriculum defines the specific objectives to be achieved within each domain at each level of general education—primary (Grades 1–6), basic (Grades 7–9), and upper secondary (Grades 10–12). Exhibit 1 outlines the objectives of each domain in primary and basic education.

Exhibit 1: Mathematics Domain Objectives, Grades 1–6 and 7–9

Educational Level	Domain	Objectives
Primary (Grades 1–6)	Numbers and Operations	Develop perceptions of numbers; Acquire principles for counting; and learn arithmetic operations and their properties, computing methods, and evaluation of results; Learn systems for expressing, comparing, and ordering numbers; and Use arithmetic operations to solve practical problems.
	Geometry and Spatial Reasoning	Develop skills essential for describing and constructing geometrical figures; Find components of geometric objects and their relationships; Classify figures in terms of their attributes; and Recognize a figure from its verbal description and create a model of It.
	Data Analysis, Probability, and Statistics	Become acquainted with elements of descriptive statistics, including ways of collecting, organizing, and interpreting qualitative and discrete quantitative data.
	Algebra	Develop skills needed to recognize correspondences and relationships between quantities; and Learn to solve algebraic expressions.
Basic (Grades 7–9)	Numbers and Operations	Deepen knowledge of integers, fractions, decimals, and percentages as preparation to (by the end of basic education) use fraction equivalence, decimals, proportions, and percentages in problem solving and real life situations; and Develop an understanding of numbers, including a basic understanding of rational numbers, and locate rational numbers on the number line.
	Geometry and Spatial Reasoning	Develop skills for measuring, comparing, and converting geometric objects while learning about geometric objects and their relationships; Find sizes of figures by indirect methods; Locate geometric objects in space using coordinates; and Develop skills in inductive and deductive reasoning and expressing and testing suppositions.
	Data Analysis, Probability, and Statistics	Use basic notions and methods of descriptive statistics to become aware of characteristics of data and to form hypotheses based on data; and Learn the basics of probability theory and the distinction between deterministic and probabilistic events.
	Algebra	Learn notions and procedures related to using variables to represent and compare unknown quantities; Use equations in problem solving; and Form a basic understanding about operations involving variables.

Science Curriculum in Primary and Lower Secondary Grades

Modern standards of general education require that students be equipped with the knowledge and skills that enable them to orient themselves amid the developing progress of mankind, use achievements of modern science, and become valuable members of society. Students should become active perceivers able to apply knowledge both for professional success and for the public good.[11]

To fulfill the above-mentioned criteria, the teaching and learning process in the sciences should do the following:

- Provoke student interest in the environment, scientific discoveries, and perception of the universe;
- Develop skills for basic science research and its application in diverse situations;
- Become aware of the connections among processes occurring in the universe;
- Develop concern and care for the environment;
- Acquire independent critical reasoning and communication skills;
- Develop self-esteem and self-control, and skills for appreciating and sharing others' opinions;
- Determine one's own place in society;
- Prepare to live a healthy and safe life; and
- Become aware of the role of science and the necessity of human collaboration for the progress of mankind.

Notably, the focus on developing attitudes and skills through research and knowledge in science teaching and learning stems not only from modern pedagogical methodology but also heavily depends on Georgian classical didactics. According to Jacob Gogebashvili, known as the Father of the Georgian National School, the main aim of teaching science is "to open for the youth compassion for nature, [and] induce love for its investigation and its contemplation." [12] Thus, the curriculum states that the aim of teaching science is "to educate students about the basics of science, give them skills to perceive the universe, become involved in different areas of society, [and] take responsibility for self, society, and the environment." [13] Specific objectives are defined in terms of knowledge, skills, and attitudes, and correspond to three levels of general education.

In terms of knowledge, general education in Georgia aspires to educate students about the following: the living world and life processes; physical and chemical processes in the universe, the Earth, and the environment; and principles of sustainable environmental development. Generally, science teaching and learning comprises interwoven domains, which aim to stimulate awareness of the connections among processes in the universe.

In primary education (Grades 1–6), there are four domains in the subject of science: Living World (elements of biology), Bodies and Phenomena (elements of physics and chemistry), Earth and the Universe (elements of geography and astronomy), and Mankind and the Environment (elements of civil education). The domains Mankind and Environment and Earth and the Universe are integrated into a life science course.

In basic education (Grades 7–9), science is subdivided into three domains: Living World (basics of biology), Physical Phenomena (basics of physics), and Chemical Phenomena (basics of chemistry). For the student cohort that participated in TIMSS 2011, the curriculum introduced chemistry in the ninth grade, which was consistent with reform efforts aimed at introducing so-called "trimester" teaching of sciences.

For each level of general education, the curriculum is narrowed down to specific content indicators which students are expected to master by the end of each respective grade. Exhibit 2 outlines these indicators of content mastery at the end of the fourth and eighth grades.

Exhibit 2: Science Indicators, Grades 4 and 8

Educational Level	Domain	Indicators
End of Grade 4	Living World	Describe the lifecycles of organisms; Discuss extinct organisms; and Relate adaptations of organisms to their environment.
	Bodies and Phenomena	Relate the equilibrium of bodies with the lever principle; Distinguish heat conductors and insulators; and Distinguish among materials and discuss their properties.
	Earth and the Universe	Determine absolute and relative positions of an object on a map; Discuss the geography of the Earth; Investigate significant geographical features of Georgia; and Describe changes in the environment caused by natural phenomena.
	Mankind and the Environment	Follow rules of social hygiene and safe behavior; Investigate the modes of life of mankind in various environments; and Perform elementary interpretation and analysis of qualitative and quantitative data.

Educational Level	Domain	Indicators
End of Grade 8	Living World	Relate the structure of the cell to its functions; Investigate specifics of organism development; Describe the transfers of energy and substance exchange in ecosystems; and Relate the diversity of organisms to the evolution process.
	Physical Phenomena (Physics)	Describe the motion of bodies; Describe the three states of matter; Perform reasoning about observable forces and the results of their activity; and Describe characteristics of pressure.

Subject mastery is far more effective when students are actively involved in observation and research and when they are able to satisfy their own curiosity by examining ready-made educational materials, searching for information, working on visual aids, and participating in interactive learning processes. Thus, in addition to theoretical knowledge, Georgia's national curriculum in science focuses special attention on developing the following specific student skills:

- Observation and Description—Determining the characteristics of objects and phenomena using one's senses and simple measuring devices;
- Accounting—Reporting and sketching observations;
- Classification—Grouping objects and phenomena according to their characteristics;
- Measurement and the Use of Quantities—Describing quantitatively, using appropriate measurement units, determining space-time relationships, and singling out variable characteristics;
- Communication—Using written and oral communication, graphs, tables, diagrams, and other means of presentation (including those involving technologies);
- Observation and Hypothesis Formulation—Expressing suppositions concerning expected consequences;
- Planning—Determining the succession of actions;
- Conducting Experiments—Choosing methodology and collecting experimental data;

- Data Interpretation—Analyzing and generalizing one's own and others' data; and
- Creation and Use of Models—Modeling of phenomena.

The national curriculum also defines the following attitudes that science teaching should nurture in every student:

- Curiosity in science subjects;
- Understanding the importance of science;
- Interest in scientific research and innovations;
- Desire to collaborate;
- Care and responsibility for the environment; and
- Understanding the significance of a safe lifestyle.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

The school year in Georgia begins in September, lasts until June, and consists of at least 180 days. The majority of schools teach five days per week with the number of lesson hours ranging from 21–36 hours per week for Grades 1–12. The National Teaching Plan defines the minimum required teaching hours for mathematics and science: at Grade 4, the minimum for mathematics is five hours per week (180 teaching hours per school year), and for science four hours per week (144 hours per year); at Grade 8, the minimum for both mathematics and science is four hours per week (144 hours per year).[14] Schools can choose to teach additional hours for any subject.

Mathematics is a mandatory subject at each level of general education. The teaching plan for science has changed several times but, for the cohort of students that participated in TIMSS, the following was effective: students studied integrated sciences in primary education (Grades 1–6); biology was a compulsory subject for Grades 7–10; physics was a compulsory subject in Grades 7–11, as was chemistry in Grades 9–12; and biology and physics were elective courses in Grade 12.

Instructional Materials, Equipment, and Laboratories

At the time of the TIMSS 2011 administration, the National Curriculum and Assessment Center was responsible for approving textbooks. Since 2011, the Education Quality Enhancement Center has assumed that responsibility. The textbook review process ensures the integrity of teaching materials within national curriculum requirements. Approved materials are not mandatory and schools are free to choose from a range of government-approved material. However, schools must use textbooks selected by their teachers for a minimum of five consecutive years.

At one time, each school had minimally equipped laboratories for science teaching and learning, but these labs were not widely used or technically supported over many years. Current efforts are underway to re-equip schools with laboratories that meet minimal standards for teaching and learning sciences.

Use of Technology

Computerization of the Georgian school system has been one of the main goals of education reform. In September 2005, MoES, with the help of Estonian counterparts, launched the Deer Leap program to facilitate the modernization of the education system in Georgia by equipping schools with information and communications technology (ICT) infrastructures and building their capacity to apply ICT in teaching and learning. Specific tasks to be achieved by the program included the following:

- Increasing access to computers and the Internet in each school;
- Increasing the availability of educational software and technical support;
- Increasing the availability and quality of technical support;
- Equipping teachers and students with relevant ICT skills;
- Enhancing integration of ICT into the curriculum; and
- Supporting the introduction of an information management system at the school district and national levels.

Since 2011, after introducing changes to the Deer Leap program, the government has provided free laptops to first grade students and supported the introduction of relevant teaching strategies using specially designed software.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Although the majority of teachers of mathematics and science in schools in Georgia are subject professionals, a scarcity of qualified staff in remote areas of the country obliges schools to assign the same teachers to teach more than one subject (e.g., mathematics and physics).

Homework Policies

There is no strict homework policy effective in the Georgian general education system. Teachers can independently choose the amount and range of homework to assign to students based on student needs and requirements, and taking into account the textbooks used.

Teachers and Teacher Education

There are several higher education institutions offering courses in education for individuals wishing to join the teacher workforce. According to the Primary Teacher Standards and the Law on General Education of Georgia, a person should complete at least a bachelor's degree in the field of education to teach at the primary level. The law also regulates eligibility requirements for teaching at the upper levels of general education (Grades 7–12), A person wishing to join the teaching profession at these levels (i.e., basic and upper secondary) should hold at least master's degree in the field of education.

In 2010, the National Examinations Center, together with the National Center for Teacher Professional Development, launched the Teacher Certification Examinations. The process is voluntary until 2014, but holding this certification is mandatory for every individual wishing to teach in schools thereafter. To earn certification, teachers must pass examinations in their respective subjects (consisting of subject content and subject-specific teaching methodologies) and professional skills.

In 2012, science teachers also will be required to pass practical exams in laboratory skills in relevant subjects. Those who successfully perform on these examinations are entitled to additional earnings above their existing salary. The Teacher Professional Development Center provides training for the laboratory exams.

Requirements for Ongoing Professional Development

In addition to pre-service education and training, teachers can participate in in-service professional development and advancement opportunities. The Teacher Professional Development Center provides teachers with the relevant training, professional development opportunities, and other resources important for their professional development and improvement. After obtaining teacher certification, teachers may choose to take examinations in computer skills and English. Upon successful completion, they can enjoy additional monetary benefits above their standard teaching salary. The center also organizes teacher professional development programs in ICT skills, and familiarity with ICT is rewarded in teacher professional development.

Monitoring Student Progress in Mathematics and Science

Before 2006, students in primary and upper secondary schools were assessed using a grading system ranging from two to five, with three being the minimal passing grade and five indicating excellence. Summative assessments were held at the end of each term, mainly in written form. Since 2006, the assessment scale has changed to a system ranging from one to ten. Teachers and schools may develop their own tests to measure student achievement in any subject.

In 2011, Ministry of Education and Science of Georgia introduced the School Leaving Examinations (SLE). To obtain a school diploma, twelfth-grade students must pass computer adaptive standardized examinations in nine main subjects. In each school, the National Examinations Center administers the examinations online. Besides the SLE, the ministry plans to introduce national assessments in other subjects in the future.

Impact and Use of TIMSS

After participating in TIMSS for the first time in 2007, the National Examinations Center developed national reports based on sciences results. These reports presented significant recommendations developed in consultation with leading mathematics and science teaching experts in Georgia. In addition to these reports, the center held informational meetings with different stakeholders to explain the Georgian results and to discuss what was needed to achieve better results in subsequent cycles of international studies. Regrettably, the findings of the study were not paid due respect and have not been reflected in educational policies developed since the TIMSS 2007 findings became available.

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Germany

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Introduction

Overview of the Education System

Germany is a federal republic consisting of 16 federal states, the *Laender*. Each *Land* (federal state) has supreme legislative and administrative power over all cultural policy issues within its geographic boundaries, including its education system. This administrative power includes regulation of curricula and time schedules, professional requirements, teacher recruitment, and quality development in schools. Some crucial aspects of the German school system (such as definition of a grade scale) are standardized through treaties. In addition, the Standing Conference of the Ministers of Education and Cultural Affairs of the *Laender* in the Federal Republic of Germany (Standing Conference) coordinates the activities of the 16 Ministries of Education and Cultural Affairs of the *Laender* in the areas of education, science, research, and culture. In this chapter, North Rhine-Westphalia, the largest *Land* in terms of population, serves as an example in cases where the specificity of particular topics makes it impossible to give a universal description for all *Laender*.

The majority of students in Germany are enrolled in public schools, which are free of charge. In the 2010-11 academic year, approximately 8 percent of all school-aged children were enrolled in institutions offering general education and approximately 3 percent of primary school students attended private schools.[1] Some private schools or boarding schools are tuition based. The *Laender* accredit, supervise, and to a certain extent subsidize all private schools.[2]

Preprimary education in Germany includes primarily children ages 3–6 and is not compulsory. Recently, however, German policy makers have acknowledged preprimary education as an essential part of the education system. The child and youth welfare sector oversees preschool education, which is provided mainly by childcare institutions (*Kindergaerten*) caring for children up to age 6. In general, preprimary education is only partially subsidized by the government, although more *Laender* and communities have been fully subsidizing the final one or two years. Since 2008, cooperation between institutions of preprimary education and primary schools has been compulsory. In 2004, the Standing Conference agreed on a binding framework for elementary education in preprimary institutions, which specifies for the first time language, reading and writing skills, and mathematics and science as explicit educational objectives.[3] For children with an immigrant background, special assessment and support programs are in place to enhance German language competencies.

Compulsory schooling for all children usually begins the year they turn six years old and involves nine years of full-time schooling (ten years in the *Laender* of Berlin, Brandenburg, and Bremen; in North Rhine-Westphalia, the duration of full-time compulsory education is nine years for the Gymnasium and ten years for other school types providing general education). In some *Laender*, children who have not yet attained an adequate developmental level to start school by age six are accommodated with school kindergarten (*Schulkindergaerten*) or preschool classes (*Vorklassen*). Over the last couple of years, a new school entry phase, called flexible school entry (*flexible Schuleingangsstufe*), has been implemented in eleven of the *Laender*. This system allows students to complete the first two class levels of primary school in one, two, or three years.

Primary school is the first level of the compulsory education system and generally covers Grades 1–4 (ages 6–10). In two of the 16 *Laender*, namely Berlin and Brandenburg, primary school covers Grades 1–6 (ages 6–12). To complete general compulsory schooling, students must, in principle, attend the local primary school. However, in some *Laender*, parents are granted the right to be involved in choosing the primary school. Children with special needs can attend a primary school if the particular institution is capable of assuring the necessary special educational and material support, and if the premises are suitable. Otherwise, children with special needs may attend special schools (*Foerderschulen*).

Throughout primary education, German (comprising instruction in reading, spelling, writing, and literature), mathematics, and *Sachunterricht* (an integrated subject of natural and social science) are considered main subjects and are mandatory in all *Laender*. Art, music, physical education, foreign language instruction, and (in most *Laender*) religious education also are taught throughout primary school.[4, 5] The total instructional time, as well as subject-specific instructional time, differs among grades and across *Laender*.

In North Rhine-Westphalia, mathematics is allocated 19 percent of the total instructional time, and natural science (mostly comprising elements of biology and geography) is allocated 9 percent, largely depending on the individual emphasis of the teacher.[6]

Traditionally in Germany, instruction in primary schools is organized for half-day attendance. However, following a rather large initiative (€4 billion, $5.3 billion USD) of the federal government, 36.9 percent of all primary schools were offering all-day schooling in 2008, which extends care and supervision for children outside lesson time and involves activities educationally related to morning lessons.[7, 8] Variations of all-day schooling include the following: fully bound form, in which all students are required to attend; partially bound form, in which only some groups of students are obliged to attend; or open form, in which individual students may attend, based on parental discretion. The majority (88.2%) of primary schools that offer all-day schooling offer it in an open form.[9]

After successful completion of primary school, children are assigned to different courses of education (*Bildungsgaenge*) according to their ability level (based on grades) and predicted academic potential.

Secondary education is divided into lower and upper secondary education. Lower secondary education starts at Grade 5 in 14 *Laender* (Grade 7 in Berlin and Brandenburg) and ends at Grade 9 or 10 (i.e., beginning at ages 10–12 and ending at ages 15 or 16). Generally speaking, students are assigned to one of three courses of education:

- Basic general education (*Hauptschulbildungsgang*)—This course of education covers Grades 5 (or 7) to 9 or 10, and its completion entitles students to proceed to vocational training or higher types of secondary school.
- Extensive general education (*Realschulbildungsgang*)—This course of education covers Grades 5 (or 7) to 10, and its completion entitles students to proceed to vocational training, upper secondary school, or a vocationally oriented upper secondary school (*Fachoberschule*) that may qualify students for universities of applied sciences.
- Intensified general education (*Gymnasialer Bildungsgang*)—This course of education covers Grades 5 (or 7) to 12 or 13, and its successful completion leads to acquisition of the General Higher Education Entrance Qualification (*Allgemeine Hochschulreife, Abitur*).

The three above-mentioned courses of education are taught either at specific types of schools (*Hauptschule*, *Realschule*, or *Gymnasium*) or at schools that offer two or three courses of education. In the 2010–11 academic year, about 17 percent of German students in Grade 8 attended a *Hauptschule*, about 25 percent attended a *Realschule*, and about 36 percent attended a *Gymnasium*.[10]

Although these school types are the most common in secondary education, several others are available in the various *Laender* and may vary considerably from this structure. For example, some *Laender* offer comprehensive schools (*Gesamtschule*) that can substitute for or compete with at least two of the previously described school types. In 2010–11, about 9 percent of German Grade 8 students attended a comprehensive school.[11]

After completing lower secondary schooling, most students follow different pathways for upper secondary education (ages 15 or 16 until 18 or 19). Assignment to the different types of upper secondary education depends on the qualifications and entitlements obtained at the end of lower secondary education. One pathway for students is full-time general education, comprising Grades 11 to 12 or 13, which leads to a higher education entrance qualification. Another pathway includes full-time vocational schooling, combined with vocational apprenticeship training at the workplace. Within this dual system, businesses providing apprenticeships contribute financially.

Improving students' basic understanding of mathematical and scientific concepts—along with enhancing proficiency in German (reading, spelling, writing, and literature) and a first foreign language—is considered crucial for lifelong learning. Therefore, mathematics and the science subjects are compulsory core subjects throughout all levels of schooling. Furthermore, a number of European, national, and regional initiatives aim at encouraging students to pursue careers in mathematics, informatics, natural sciences, and technology.[12] These four subjects are usually referred to as the MINT-subjects.

At the national level, some of these initiatives are associated with the High-Tech Strategy, which was launched by the Federal Ministry of Education and Research in 2006. The strategy aims to support the development of new products, innovative training, and continuing education services to meet increasing demands for skilled workers.[13] Additionally, a list of recommendations, issued by the Standing Conference in 2009, provides the basis for implementing related programs in the education system. This recommendation, accompanied by a number of provisions, emphasizes the importance of supporting education in the MINT-subjects, including improving society's image of science, supporting science education in early childhood education, changing curricula and teaching approaches at the primary and secondary levels, and creating opportunities for continuing professional development for science teachers (see Impact and Use of TIMSS).[14]

These policy documents are complemented by many initiatives and programs, such as the following: Science Days, which focus on career orientation and are usually organized by associations, societies, or foundations; targeted education programs at museums of technology or natural science; mathematical and scientific competitions, such as Youth Research (*Jugend forscht*); and university activities for children (e.g., touring the university and participating in Children's University lectures), or special vacation academies to support the talent and development of youth in MINT-subjects.[a] Some of these programs, such as Girls' Day and Boys' Day, provide gender-specific career orientation.[15, 16] Additionally, the National Pact for Women in MINT Professions—a program that aims to increase the proportion of women in MINT careers—sponsors projects targeted to girls and women.[17]

There is no nationally implemented special funding for mathematics and science. However, programs selectively address individual schools or regions.

Languages of Instruction

In the Federal Republic of Germany, the official language of administration and the judiciary is German. In accordance with the European Charter of Regional and Minority Languages of the Council of Europe, languages of minority groups with a history of residence in Germany (e.g., Danish, Friesian, Sorbian, Romany, and Low German) are acknowledged regionally as official languages.[18] The demographic, cultural, and social heterogeneity in Germany differs among regions. Overall in 2010, 19 percent of the total German population and 31 percent of children ages 5–15 had an immigrant background.[19] Apart from German, Turkish and Russian were the most commonly spoken languages in families of fourth grade students.[20]

Although there are no legislative provisions on the language of instruction, German is usually the language of instruction in preprimary schools, general education and vocational schools, and institutions of higher education. Exceptions include some private schools, bilingual schools and classes, or extra classes offered in the mother tongue for students whose native language is not German.[21]

a For more information on *Jugend forscht*, please visit https://www.jugend-forscht.de/

The German Curricula in Primary and Lower Secondary Schools

The Standing Conference has agreed upon national educational standards (*Bildungsstandards*), beginning with primary school, and all 16 *Laender* have committed to implementing these standards by establishing core-curricula. These educational standards serve as objectives that are binding for all *Laender*, and they specify the curricular elements for core subjects that are to be achieved by students after a defined number of school years. The Ministry of Education and Cultural Affairs in each *Land* manages the curricula. As a result, almost every *Land* has its own curricula for specific courses of education, subjects, and grade levels.

The national educational standards determine the curricula for primary and secondary mathematics and for secondary science (except geography). There are no nationwide standards for science education at the primary level. The respective Ministries of Education and Cultural Affairs in each *Land* publish the curricula as regulations that are binding for teachers, and head teachers are responsible for ensuring compliance. The curricula are formulated in a general way, allowing teachers considerable freedom with regard to content, objectives, and teaching methods. Teachers of a particular subject are encouraged to work together to reach consensus on the instructional methods and assessment criteria used in subject-specific or generalized school curricula.

Mathematics Curriculum in Primary and Lower Secondary Grades

Mathematics education at the primary school level is currently regulated across the 16 *Laender* by 13 different curricula determined by the national educational standards. Although twelve *Laender* have passed their own curricula, four *Laender* (Berlin, Brandenburg, Bremen, and Mecklenburg-Western Pomerania) collaborated in developing and approving a common core-curriculum. Exhibit 1 presents an overview of the mathematics topics taught in primary school in the *Land* North Rhine-Westphalia.

Exhibit 1: Example Mathematics Curriculum Guidelines for the Primary Level, Up to Grade 4, in North Rhine-Westphalia

Expectations for Content-based Competencies by the End of Grade 4: Summary of expected competencies at the end of the school entry phase (Grades 1 and 2) and at the end of Grade 4	
Numbers and Operations	**Students…**
Understanding Numbers	Illustrate the number range up to 1,000,000 using the decimal system; Analyze and describe structural relations between different number systems based on examples; Use structures in number systems to understand numbers in extended number ranges; Work in the number range up to 1,000,000 by counting in steps as well as by arranging and comparing numbers according to various characteristics; and Discover relationships between individual numbers and sets of numbers, and describe these by using mathematical terminology and symbols.
Understanding Operations	Match basic situations (which require adding and combining or taking away and separating) to the respective basic operations such as addition, subtraction, or completion; Match basic situations (which require repeated addition of the same numbers or repeated subtraction of the same numbers) to the respective operations, such as multiplication or division (distribution); Switch between different representations of operations, (e.g., material, symbolic, figurative, or language-based representations); Discover and describe characteristics of operations and laws of arithmetic based on examples; and Use mathematical terminology and symbols correctly.
Fast Mental Arithmetic	Have sound knowledge and skills of quick mental arithmetic with numbers up to 1,000,000; and Repeat all multiplication tables (up to 10) automatically and reverse the operations fluently.
Arithmetic	Solve problems using all four basic operations (orally or partly standardized on paper) by making use of arithmetic laws and analyze strategies using relationships between numbers and arithmetic laws (e.g., distributive law and commutative law of addition) in all four operations; Solve problems using multiplication table relationships; and Describe and evaluate different arithmetic operations and demonstrate clear understanding of these structures in writing.
Numerals	Explain in writing operations such as addition (with several addends), subtraction (with one subtrahend), multiplication (with multiple digits), and division (by using remainder notations with single digit and important double-digit divisors) by describing the separate calculation steps logically through examples; and Calculate fluently, confidently, and in written form using addition, subtraction, and multiplication.
Estimations	State approximate results of calculations using numbers up to 1,000,000 and round and estimate with an accuracy appropriate to the task.
Flexible Calculating	Use methods of own preference to make calculations, or use a standard method, with and without a calculator.
Dimension and Form	**Students…**
Spatial Orientation and Spatial Visualization	Trace lines with a pen (eye-hand coordination), name overlapping figures (figure-ground discrimination), and identify forms (visual consistency); Orient themselves in two-dimensional space using a map; Describe spatial relations on the basis of pictures, arrangements, and plans, as well as from imagination; and Imagine movement of shapes and objects and describe the result of the movement in advance.

Expectations for Content-based Competencies by the End of Grade 4: Summary of expected competencies at the end of the school entry phase (Grades 1 and 2) and at the end of Grade 4	
Shapes	Explore shapes, name them, and use mathematical terminology (e.g., perpendicular, horizontal, parallel, square) to describe them; Construct shapes by replacing, overlaying, or spreading elements, filling in spaces, taking apart, and continuing patterns; Continue patterns (e.g., band ornaments, tessellations), describe them, and construct own patterns; Name and compare areas of shapes and their perimeters; and Construct similar shapes from card paper by enlarging or reducing according to scale.
Solid Figures	Recognize and name geometric shapes, sort them according to geometric characteristics, and use the following mathematical terminology to describe them: area and edge; Construct models of objects (wireframe and solid models) and more complex cube constructions; Find various nets for cubes; Identify two- or three-dimensional views of buildings and construct buildings according to a plan; and Define and compare volumes of objects using unit cubes.
Symmetry	Examine shapes for axial (line) symmetry and use their characteristic length preservation and space preservation to explain the symmetry; and Construct symmetrical figures and use characteristics of axial (line) symmetry (length preservation and space preservation).
Drawing	Construct line segments, simple figures, patterns, curves, and exact parallel or perpendicular lines using instruments such as compasses and triangles, and use grid or point patterns to draw shapes and three-dimensional buildings.
Measuring and Quantities	
	Students…
Perception and Handling of Quantities	Measure quantities (lengths, time intervals, weights, and volumes) using suitable drawing instruments; Compare and organize quantities; Name quantities of familiar objects and use these quantities as a reference for estimations; Read time from analog and digital clocks; Use monetary units (c, €), lengths (mm, km), time intervals (s, min, h), weights (g, kg, t), and volumes (ml, l) and convert between units; Convert fractional quantities that occur in everyday life into the next smaller unit (e.g., ¼l = 250ml); and Calculate with quantities (also with decimals).
Factual Situations	Formulate arithmetic questions for real or simulated situations (also in project-oriented problem contexts) and for contextual tasks, and solve them; Use aids such as tables, drawings, and diagrams to solve problems; Reason that estimated values (estimation, evaluation) are sufficient and explain why an exact result is unnecessary or necessary; and Construct contextual problems (orally and in writing) for mathematical models (equations, tables, etc.).
Data, Frequency, Plausibility	
	Students…
Data and Frequency	Collect data from real-life situations and present this information in diagrams and tables; and Retrieve data from calendars, diagrams, and tables to answer arithmetic questions.
Probability	Describe the probability of simple events (e.g., using terms such as: certain, possible, impossible, always, often, rarely, and never); and Name the number of different possibilities in simple combination tasks.

Expectations for Content-based Competencies by the End of Grade 4: Summary of expected competencies at the end of the school entry phase (Grades 1 and 2) and at the end of Grade 4	
Expectations for Process-oriented Competencies	
Problem Solving—Being Creative	**Students…**
Select	Find information relevant for the solution of problems and describe it in their own words.
Solve	Try progressively more systematic and result-oriented approaches and use knowledge of operations to solve problems.
Reflect and Check	Check results for adequacy, detect and correct mistakes, and compare and evaluate various approaches.
Transfer	Transfer approaches to similar situations.
Modify and Invent	Invent tasks and questions.
Apply	Choose suitable arithmetic rules, algorithms, and tools to solve problems and use them appropriately.
Modeling	**Students…**
Detect	Distill information from problem situations and tasks and decide between relevant and non-relevant information.
Solve	Transfer information from problem situations into a mathematical model and solve these problems with the help of this model.
Validate	Relate solutions back to the problem situation and test plausibility of results.
Relate	Define suitable problems for given mathematical models and develop questions related to the models.
Arguing	**Students…**
Hypothesize	Make hypotheses about mathematical relationships or irregularities.
Test	Test hypotheses using examples and question if assumptions, solutions, statements, etc. are correct.
Conclude	Prove or disprove hypotheses based on examples and develop preliminary conclusions related to these hypotheses.
Substantiate	Describe relationships and rules based on examples and follow the reasoning of others.
Illustrating—Communicating	**Students…**
Record	Record results, procedures, and learning experiences.
Present and Exchange	Design and develop suitable means of presentation, such as transparencies or posters, to comprehensively present solutions, ideas, and results.
Cooperate and Communicate	Work on complex tasks together, organize meetings, an combine own opinions with that of others.
Use Expert Terminology	Use suitable mathematical terminology to present mathematical facts, symbols, and conventions.
Change between Illustrations	Transfer one illustration into other forms of illustrative representation.

At the secondary school level, eighth grade mathematics education is currently regulated by more than 40 different curricula, which are all determined by the national educational standards. There are no common core-curricula across the *Laender*. In addition, the curricula differ across grades and courses of education with respect to the detail of the content covered and the timing of introduction, with introduction occurring earlier in the more demanding courses of education. In the *Land* North Rhine-Westphalia, the curricula of the various courses of education divide into content-based and process-based competency expectations at the eighth grade level. The *Gymnasium* also covers competency expectations in the area of reasoning-communicating (e.g., relate terms and methods). Whereas expectations for process-based competencies differ only marginally among courses of education, differences in expectations for content-based competencies are rather significant. The main difference in the curriculum of the *Gymnasium* lies in the expectation that students should reach these competency expectations at an earlier stage of learning than in the curricula of the *Realschule* or *Hauptschule*. For example, the topic of linear equations is part of the competency expectations in Grades 7 or 8 at the *Gymnasium* but in Grades 9 or 10 at the *Realschule,* while at the *Hauptschule* it is included only in the Grade 10 qualifying courses that prepare students for the general education school-leaving certificate. A special feature of the *Hauptschule* curriculum, but not of the *Realschule* or *Gymnasium* curricula, is a chapter titled "References for Language/Communication-Sensitive Teaching" that differentiates among various communication and word activities (e.g., name, define, describe).

Exhibit 2 presents an overview of mathematics topics covered in the eighth grade curriculum for the *Realschulbildungsgang* (extensive general education) in the Land North Rhine-Westphalia, and is fairly representative of the 40 eighth grade curricula in place in the *Laender*.[22]

Exhibit 2: Example Mathematics Curriculum Guidelines for the Realschulbildungsgang, Grade 8, in North Rhine-Westphalia

Expectations for Content-based Competencies	
Arithmetic and Algebra—Dealing with numerals and symbols	**Students…**
Ordering	Order and compare rational numbers.
Operating	Execute basic arithmetic operations on rational numbers (mental and written arithmetic techniques); Aggregate terms, multiply them, and factor them using simple factors; and Solve linear equations by trial and error, as well as algebraically, and check calculations by substitution.
Applying	Apply knowledge of rational numbers and simple linear equations to problem solving of both inner- and extra-mathematical problems.
Systematizing	Give non-mathematical reasons and examples for the extension of the set of natural numbers to the set of rational numbers.
Functions—Describing and investigating relationships and changes	**Students…**
Illustrating	Express relationships in their own words, in tables of values, as graphs, and in mathematical symbols and shift among different forms of representation.
Interpreting	Interpret linear functions in terms of equations and graphs.
Applying	Identify proportional, non-proportional, and linear relations in charts, mathematical symbols, and real-world situations; Apply the characteristics of proportional, non-proportional, and linear relations, as well as simple procedures of the Rule of Three for the solution of mathematical and non-mathematical problems; and Compute percentages and base values in real world situations.
Geometry—Comprehending dimension and form of two- and three-dimensional figures	**Students…**
Conceptualizing	Name and characterize triangles (right, isosceles, and equilateral), parallelograms, rhombi, trapezoids, and simple prisms and identify them in real-world situations.
Constructing	Draw triangles from given measures of angles and sides; and Sketch angular illustrations, create nets of cubes and cuboids, and construct geometrical objects.
Measuring	Estimate and define the perimeter and area of triangles, parallelograms, and figures constituted by these shapes; and Specify surface areas and volumes of cubes, cuboids, and simple prisms.
Applying	Discern 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 surveys, and use spreadsheets for data organization.
Illustrating	Use median, range, and quartiles for the description of frequency distributions.
Analyzing	Use simple experiments of chance to describe stochastic events in everyday situations; Use relative frequencies from several repeated experiments to estimate probability; and Use the Rule of Laplace to ascertain probabilities in simple experiments.
Evaluating	Use probability to evaluate chances and risks and to estimate frequencies; and Interpret the range and quartiles in statistical illustrations or descriptions.

Expectations for Process-based Competencies	
Reasoning and Communicating—Communicating, presenting, and reasoning	**Students…**
Reading	Gather, restructure, and evaluate information from simple mathematical figures.
Verbalizing	Demonstrate individual problem solving steps using simple mathematical operations in their own words and using appropriate technical terms.
Communicating	Compare and evaluate approaches, solutions, arguments, and illustrations.
Presenting	Present solutions in short prepared statements.
Associating	Find generalizations and specific instances of mathematical facts, and give examples and counterexamples to support findings.
Reasoning	Use mathematical knowledge to reason using multistep arguments.
Problem Solving—Understanding, investigating, and solving problems	**Students…**
Investigating	Analyze patterns and relationships in numbers and figures and make hypotheses based on them.
Solving	Plan and describe a problem solving approach; Use algorithms to solve standard mathematical problems and evaluate answers in terms of practicality; Examine multiple ways to solve a problem; Use problem-solving strategies; and Apply various forms of representation (e.g., charts, sketches, equations) when solving problems.
Reflecting	Examine and evaluate results by means of plausibility, rough calculations, or sketches to verify solution procedures.
Mathematical Modeling—Creating and applying models	**Students…**
Modeling	Translate simple real-world situations into mathematical models.
Validating	Verify results generated through the mathematical model by comparing them to the situation and, where necessary, modify the model.
Implementing	Match a mathematical model (e.g., chart, graph, equation) with a suitable real-world situation.
Instruments—Using technologies and instruments	**Students…**
Investigating	Use spreadsheets and geometry software to investigate mathematical and non-mathematical relationships.
Calculating	Use a calculator.
Illustrating	Compile data electronically and depict it using spreadsheets.
Researching	Use dictionaries, textbooks, and the Internet to acquire information.

Science Curriculum in Primary and Lower Secondary Grades

Science education at the primary school level is currently regulated by 14 different curricula. The curricula are not determined by the national educational standards. Whereas 13 *Laender* have designed their own curricula, three *Laender* (Berlin, Brandenburg, and Mecklenburg-Western Pomerania) have collaborated in developing and approving a common core-curriculum.

In the curriculum for *Sachunterricht* of the *Land* North Rhine-Westphalia, educational objectives are described as content-based as well as process-based competency expectations. The curriculum is divided into five topics: Nature and Life; Technology and Work Environment; Space, Environment, and Mobility; Man and Society; and Time and Culture. Science subjects are assigned to Nature and Life, but the other topics also touch on science-related questions. Every topic is structured into five or six themes.

Exhibit 3 is an example of an overview of one science topic and curriculum focus at the primary school level in the *Land* North Rhine-Westphalia, a fairly representative curriculum for the 16 *Laender*.[23]

Exhibit 3: Example Science Curriculum Guidelines for the Primary Level (up to Grade 4) in North Rhine-Westphalia, Topic: Nature and Life

Expectations for Competencies: Summary of expected competencies at the end of the school entry phase (Grades 1 and 2) and at the end of Grade 4	
Topic: Nature and Life	**Students…**
Materials and Their Transformation	Collect animate and inanimate materials from nature and organize them according to specific criteria; Examine the characteristics of materials and describe similarities and differences; and Examine visible material changes of animate and inanimate objects, present results, and describe them (states of matter (e.g., water), dehydration processes of fruits, solubility of solids, and chemical transformations through combustion).
Heat, Light, Fire, Water, Air, and Sound	Discover characteristics of heat, light, fire, water, air, and sound through experimentation; Observe and describe the importance of water, heat, and light for humans, animals, and plants; Plan an experiment and evaluate results; and Describe changes in nature (e.g., the water cycle, seasons).
Magnetism and Electricity	Examine the effects of magnets on various materials and describe them; and Construct simple electric circuits and describe, explain, and follow safety rules when using electricity.
Human Body, Senses, Nutrition, and Health	Examine and describe the meaning of the five senses in daily life; Identify and describe the functions of individual sensory organs; Identify and describe different nutrition habits and their effects; Describe the structures and basic functions of the human body systems (blood circuit, respiration, digestion); Describe the basics of hygiene, healthy nutrition, and a healthy lifestyle; and Formulate rules and advice for living a healthy lifestyle.
Animals, Plants, and Their Habitats	Identify the body structures and living conditions of animals and document the observations; Observe and name plants and their typical characteristics and describe their habitats; Describe the development of animals and plants; and Describe relationships between habitats and living conditions for animals, humans, and plants.

For most courses of education at the secondary school level, science education is taught as the following separate subjects: biology, chemistry, physics, and geography. Only some *Laender* offer for some courses of education (mostly at *Hauptschulen* or *Gesamtschulen*) science as integrated subject(s), covering some or all subjects.

Eighth grade science education is currently regulated by over 40 different curricula, which (with the exception of geography) are determined by the national educational standards. Common core-curricula across some *Laender* were introduced in 2011. However, these new core-curricula have not been taken into consideration in this chapter because they were not relevant for the students assessed at the time of TIMSS 2011. The curricula differ across grades and courses of education, with the more demanding courses of education covering content earlier or in more detail. Some content (e.g., thermodynamics) is covered only in the more demanding courses of education.

Exhibit 4 presents a representative overview of topics covered in biology, chemistry, physics, and geography from the eighth grade curriculum for the *Realschulbildungsgang* (extensive general education) in the *Land* North Rhine-Westphalia.[24, 25, 26, 27]

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Materials, Equipment, and Laboratories

The Ministry of Education and Cultural Affairs for each *Land* is responsible for the approval of instructional materials. North Rhine-Westphalia uses three authorization practices: general approval, simplified approval, and approval by advisory opinion.[28] These three practices differ by subject, grade, and school type. In the case of general approval, the decision about the appropriateness of instructional materials is made at the school level. This practice applies to almost all supplementary instructional materials, such as maps, lists of mathematical formulas, periodic tables of the elements, scientific literature, and encyclopedias. In the case of simplified approval, the publishing house declares that the materials are in accordance with the curricula and related policies. The Ministry of Education and Cultural Affairs performs a selective review of the quality of the material. This practice applies to all instructional materials for the *Sachunterricht* at the primary school level.[29] In the case of approval by advisory opinion, the authorization process requires both a quality review by an independent expert and the consent of the ministry to adopt the material.

Exhibit 4: Example Physics, Biology, Chemistry, and Geography Curriculum Guidelines for the *Realschulbildungsgang*, Grades 7 and 8, in North Rhine-Westphalia, Selected Topics

Examples of Topics	
Physics: Force and Energy	
Forces are Recognized by their Effects	Change of motion and deformation of solids impacted by a force; Force as a quantity (static measurement of force, Newton as a unit); Force and interaction; Force exerted by muscles; Vector representations of forces; Weight and gravity; and Friction.
Physics: Light and Image	
Refraction of Light	This phenomenon is experienced and interpreted based on examples; Total reflection (phenomena in nature: layers of air with different temperatures, looking up from the bottom of a swimming pool, optical fibers and news broadcasts); and Lenses (convex lens, focal point, experiments on light paths and lens images, experiments on concave lenses).
Biology: Life in Ecosystems	
Different Plants and Animals in the Forest	Exploration walks; Work with microscopes and binoculars; Simple experiments on soil analysis, Berlese apparatus (used to trap soil-dwelling insects); Observation reports; Increase knowledge of species; Determine, compare, and interpret different measurements (e.g., of light, wind, water); Relevance of moss for water balance, and ferns; Relations among physical features and behavior, nutrition, and reproduction; and Nutritional relations (food chains, food nets, and food pyramids).
Biology: Everybody is Responsible for his or her own Health	
Illness can have Different Reasons and Effects	Causes and effects of illnesses using examples; Course of an infectious disease (e.g., a typical childhood disease, colds); Explanation of the following terms: infection, incubation period, convalescence, and immunity; and Circulation of diseases as a result of global tourism (e.g., malaria).
Chemistry: (Choice of compulsory topics)	
	Properties of materials; Separation of mixtures into pure materials; Separating and mixing as important and common methods in everyday life and technology; Changing states of matter by changing pressure or temperature; Changing materials into other materials by chemical reactions; The unchanged mass of materials involved in chemical reactions; Breaking down compounds into their elements; and The atomic consistency of molecules.
Geography: Zoning of the Earth	
The Earth as a Celestial Object	Day and night and seasons; Temperature zones of the Earth; and Basic features of the Earth's wind systems.
Geography: The Earth – A Restless Planet	
Geographical Changes on the Surface of the Earth	Formation and erosion of mountains; Erosion and sedimentation; and Glacial morphology.

This approval practice applies to instructional materials for mathematics at both the primary and the secondary school level, as well as to the different science subject materials at the secondary school level.[30] The information about materials approved for instruction is published on the Internet.[31] Teachers are free to choose materials from the approved list that best complement their chosen teaching methods.

Generally speaking, mathematics and science classroom equipment and materials vary depending on school policy and teacher commitment. Laboratories are rare in primary schools; only about 8 percent of the German primary schools participating in TIMSS 2007 reported having one. At the secondary school level, laboratories are more common; however, about 44 percent of the school principals from schools participating in PISA 2009 reported a shortage of science laboratory equipment.[32] It should be noted that only larger schools have single- or specific-purpose rooms for science. In some schools, rooms with multiple functions, such as kitchens or craft rooms, may be used for science laboratory space.

Use of Technology

Computer workstations or laptops are available in about two-thirds of all schools. In primary schools, the ratio of students to computers is approximately 5:1 (of which 65 percent were connected to the Internet).[33] There is no national policy concerning use of computers and calculators in mathematics education. However, in most *Laender*, the mathematics curriculum includes broad guidelines regarding the use of calculators. In North Rhine-Westphalia, students use computers in moderation if the quality of the software does not contradict the pedagogical philosophy of the curriculum; students use calculators in moderation beginning in the fourth grade. Policy documents increasingly emphasize new media (multimedia) as a teaching aid, as a subject, and as a personal skill students should acquire. Some *Laender*, such as North Rhine-Westphalia, have introduced the topic Media as Sources of Information as a separate content area in the curriculum for *Sachunterricht* at the primary school level.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Teachers in primary schools are expected to teach in all major subject areas (German, mathematics, and *Sachunterricht*), even if they were not specialized trained for these subjects. In North Rhine-Westphalia, however, at least some coursework in basic mathematics education is compulsory for all teachers during the first phase of teacher education. At the secondary school level, specialist teachers teach mathematics and science subjects at the *Gymnasium* and the *Realschule* but not necessarily at the other types of schools.

Homework Policies

There is no nationally uniform homework policy in Germany. In North Rhine-Westphalia, the Ministry of Education and Cultural Affairs has issued a decree that regulates homework policy. Homework should take 30–60 minutes outside lesson time at the primary school level and 90–120 minutes at the secondary school level. No homework may be assigned from Saturday through Monday. Teachers should review homework regularly.[34]

Teachers and Teacher Education

Teachers are employed by the Ministries of Education and Cultural Affairs of the *Laender* on a full-time or part-time basis. In the 2010–11 academic year, about 71 percent of general education teachers and 87 percent of primary school teachers were female.[35] Teachers in Germany tend to be older than those in other OECD countries.[36] In 2010–11, 48 percent of general education teachers and 25 percent of primary teachers were 50 years or older.[37] In 2010, about 80 percent of the teachers in Germany had civil-servant status.[38] However, there is ongoing debate in some *Laender* about whether that status should be retained. As a result, some *Laender* have suspended or abolished the civil-servant status of new teachers. The percentage of teachers with civil-servant status differs among the *Laender,* as do teachers' working hours and salaries.

The individual *Laender* regulate teacher education, although a resolution agreed on by the Standing Conference guarantees recognition of university examinations for the teaching profession in the different *Laender*. Teacher education in Germany has recently been restructured from a course of study ending with state examinations into a course of study culminating in a bachelor's or master's degree, but most teachers involved in TIMSS 2011 would have been educated within the prior system. Therefore the former structure of teacher training is presented below.

Teacher education in Germany is offered through universities, education colleges, and art and music colleges. Admission to a teacher education program requires the higher education entrance qualification (in most cases, the *Abitur*). Teacher education is structured in two phases, both of which terminate in a state examination (First and Second State Examination). Passing the First State

Examination is a precondition for admission to the second stage, and teachers are officially qualified to practice only after taking the Second State Examination.

The first stage of teacher education (6–7 semesters for primary school teachers and up to 9 semesters for secondary school teachers, or 3–4.5 years) is part of the first stage of tertiary education. It includes at least one practical training period of several weeks and incorporates general didactics or a subject related didactics placement. The second stage, *Referendariat*, usually lasts one and a half to two years and consists mostly or partly supervised pedagogical training conducted in the classroom.

Teacher Education Specific to Mathematics and Science

Within teacher training, the amount of required mathematics and science education and pedagogical training varies depending on the particular *Land* and school type (primary versus secondary schools, as well as intensified general education versus basic and extensive general education at the secondary level). In North Rhine-Westphalia, primary school teachers spend 20–40 percent of their total time studying mathematics and 25 percent studying educational science. The remaining time is spent studying other subjects of their choosing, which may include science. For primary school teachers, no specific amount of science education is required. Secondary school mathematics and science teachers spend about 40 percent of their total time studying their first major subject, another 40 percent studying their second major subject, and 20 percent studying educational science.[39]

Courses in educational science usually comprise general and school pedagogy, as well as psychology. Additionally, students may choose among philosophy, sociology or political science, and theology. Occasionally, if there are staff shortages, personnel without formal teacher training may be employed. In 2007, 2.3 percent of all newly recruited teachers in the public school sector had no formal teacher training.[40]

Requirements for Ongoing Professional Development

To ensure ongoing professional development, teachers are required to participate regularly in training and development. Although professional development is regulated differently in the 16 *Laender*, there is ample opportunity for teachers to participate, and teachers are mostly free to choose the content and quantity of the courses, programs, and workshops they want to attend. Teacher professional development focuses on keeping teachers up-to-date in the subjects they teach and the teaching methods used, as well as in the broader fields of psychology and sociology in education.

Monitoring Student Progress in Mathematics and Science

National Assessments

Since 2007, all *Laender* have administered the following cross-*Laender* comparative studies (*Vergleichsarbeiten*): in mathematics and German in Grade 3; and in mathematics, German, and the first foreign language (English or French) in Grade 8.[41] The test items are developed by the independent Institute for Educational Progress (*Institut zur Qualitaetsentwicklung im Bildungswesen*, or IQB), which was established by the Standing Conference in 2003. These cross-*Laender* comparative studies are administered like regular classroom tests, although they also serve as standardized school achievement tests based on the national educational standards (*Bildungsstandards*). The test results provide teachers with information about the strengths and weaknesses of their students, as well as subject-specific pedagogical and educational psychology recommendations to improve their instruction.

In 2011, a sample-based study was conducted to compare students' skills in mathematics across all 16 *Laender*. Subsequent comparisons will be carried out every five years.[42]

Use of Grades, Marks, and Report Cards

In state-run schools, teachers monitor individual student progress continuously throughout the academic year. The evaluation of a given student's performance in a particular class is based on all of the work the student has done in that class—specifically, written, oral, and practical work and tests. Oral work refers to a student's verbal contributions and is evaluated in class. In such subjects as sports, music, or arts and crafts, practical achievements serve as the basis of evaluation. In addition, teachers can make use of the feedback they receive in the context of the cross-*Laender* comparative studies.

In Grades 1–2, the focus is on direct observation of students; written class tests are gradually introduced beginning in Grade 2 in certain subjects (especially German, and mathematics, and *Sachunterricht*).

In general, individual student progress and development are documented and defined within performance standards for each subject in report cards given to students and their parents twice a year (in the middle and at the end of the school year). The structure and content of these school report cards vary across the *Laender*. In some *Laender*, report cards contain feedback concerning in-class participation and social conduct within the school in addition to the grades awarded for individual subjects. Teachers in most schools also discuss the child's progress and behavior with parents during Parent-Teacher Day.

According to a resolution agreed on by the Standing Conference in 2010, teachers are asked to develop special monitoring and feedback methods for low-performing students. These methods comprise individualized learning plans as well as intensified and individualized monitoring activities, such as the documentation of progress in learning diaries or language portfolios.[43]

Classroom Tests

Generally speaking, primary and secondary schools in all *Laender* conduct oral and written examinations at regular interval throughout the school year, which are used in all school types to monitor student learning. Examinations are always based on curriculum requirements, as well as on the level of knowledge, abilities, and skills students should have acquired in class. These examinations are used as one basis for report cards, which have consequences for individual students, such as for promotion to the next grade or entry to a higher school system or university. In all *Laender*, students are automatically promoted from Grade 1 to Grade 2. From Grade 2 onward, students might need to repeat a year if their progress is insufficient, although promotion polices after Grade 2 differ among the *Laender*. Overall, in the 2010–11 school year, only 0.5 percent of all students in primary education repeated a year.[44]

Impact and Use of TIMSS

After an absence of systematic system monitoring for almost 20 years, Germany took part in the IEA International Reading Ability Study (RLS) in 1990–91 and in TIMSS 1995 (Grades 7 and 8, and students in their final year of secondary school).[45] In subsequent years, Germany took part in the IEA Civic Education Study (CIVED), all cycles of PISA, and PIRLS.[46, 47] In 2007, Germany participated in TIMSS with fourth grade students for the first time. Currently, Germany is taking part in both TIMSS 2011 (again Grade 4 only) and PIRLS 2011, making use of the national option to administer both assessments to the same fourth grade students in the same schools, usually on two consecutive days.

When mapping and contextualizing TIMSS within Germany's major policy discussions and changes, educational researchers can identify four areas of influence: the introduction of system monitoring; [48] the introduction of nationwide educational standards; [49] the increase in empirical education research; [50, 51] and the launch of programs for the evaluation and development of the mathematics and science curricula. Focusing on the latter area only, several *Laender*, foundations, and other organizations have introduced a number of initiatives and programs that promote education in mathematics and science, in direct response to Germany's TIMSS results from 1995 or 2007.[52]

A number of initiatives are widespread. Among these is Enhancement of the Efficiency of Mathematics and Science Education (*Steigerung der Effizienz des mathematisch-naturwissenschaftlichen Unterrichts*, or SINUS), a model program to increase the efficiency of the mathematics and science curricula. It was introduced in 1998 by the Commission for Education Planning and Research Development of the Federal Republic and the *Laender* as a direct consequence of the TIMSS 1995 results. The third round of the program began in 2007. The project aims to create cooperative structures among teachers in both primary schools (13 *Laender* participating) and institutions of lower secondary education (11 *Laender* participating). The SINUS at Primary Schools 2009–13 (*SINUS an Grundschulen*) is the current project addressing primary schools.[53] Similar projects include the following: Physics in Context (*Physik im Kontext*), with eleven *Laender* participating; Chemistry in Context (*Chemie im Kontext*), with twelve *Laender* participating; and Biology in Context (*Biologie im Kontext*), with nine *Laender* participating.[54]

In addition, several MINT-initiatives were founded to promote science as a subject for teachers as well as for students. One recent example (2009–13) is a project financed by the German Telekom Foundation to support four universities in implementing new concepts and ideas for the initial education of teachers in mathematics, science, and technical subjects (MINT teacher education). One example for primary school is the PIK AS project, a cooperative project to develop mathematics instruction in primary schools. The project consists of support for mathematics specific pedagogy (process and content-related competences), and school development (initiation of subject-related school development). The aim of PIK AS is to support teachers and professional development trainers in implementing the new mathematics curriculum for North Rhine-Westphalian primary schools.[55, 56]

Suggested Readings

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Ghana

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Introduction

Overview of the Education System

In Ghana, the Ministry of Education is responsible for the formulation of educational policy. The ministry ensures that the implementation of policy is in accordance with educational aims and objectives.

To improve the management and administration of pre-tertiary education in the country, Ghana's education system has been decentralized into a six-tier system: school, circuit, district, regional, national, and the ministry. For ease of education delivery, schools are organized into circuits (groups of schools within a district), with circuit supervisors and assistant directors providing external supervision. District education offices, established in each of the country's 170 districts, are autonomous and managed by district directors of education. Regional inspectors monitor and inspect secondary schools and colleges. At the national level, 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 of the Ghana Education Service works in collaboration with the regions and districts to establish guidelines for inspecting senior secondary-high schools. The inspectorate also conducts comprehensive inspections, monitoring schools, investigating complaints, and approving courses and programs in pre-tertiary schools in the country.[1, 2]

The Ghana Education Service, under the Ministry of Education, is responsible for implementing approved pre-tertiary education policies and programs through decentralization at the metropolitan, municipal, and district levels.[3, 4] 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) and the Education for All program goals, based on the *World Declaration on Education*, which focuses on meeting students' basic learning needs.[5] Ghana's national policy on education also emphasizes mathematics, science, and technology education in the *Education Strategic Plan* policy goals.

In particular, the 2010 National Science and Technology Policy emphasizes the teaching and learning of science and technology in order to accelerate Ghana's development.[6] This new policy states that science should be taught as natural science in the lower primary level and as an integrated science at the upper primary and junior high school levels.[7] The policy has led to the appointment of science, technology, and mathematics education coordinators in the 170 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 has been established, along with Science Resource Centers in each region. The centers offer both teachers and students access to science laboratories and libraries in addition to periodically organized clinics or workshops.

Head teachers or principals are responsible for the internal management of education within schools. Also, at the basic education level, communities in which these schools are located take part in drafting and implementing policies on education and governance through School Management Committees and Parents and Teachers Associations; at the senior secondary level, this is the responsibility of a school's Board of Governors.

Schools or educational institutions in the country are funded based on ownership; the government funds public schools while private owners fund private schools. Generally, the government is primarily responsible for funding education in Ghana, with additional assistance from the following stakeholders: metropolitan, municipal, and district assemblies, as well as donors and educational partners. Expenditure on education, which is approved by Parliament, is between 28 and 40 percent of the national annual budget.[8, 9]

Ghana's education system comprises four levels: basic education, secondary education, tertiary education, and non-formal education. At the basic education level, education is compulsory and tuition-free, as stipulated by the Free and Compulsory Universal Basic Education policy. The two levels that pertain to TIMSS 2011—basic and secondary education—are described below.

Level one of basic education consists of a two-year preschool (part of the new education reform), two-year kindergarten, six-year primary school (Grades 1–6), and three-year junior high school (Years 1–3, or Grades 7–9).[10] Children ages 4 and 5 are enrolled in kindergarten and, at age 6, enter primary school. The final level of basic education—junior high school—introduces children to basic scientific, technical, and vocational knowledge and skills. Most preschools in the country are owned by private individuals, communities, non-governmental organizations, and churches; all other preschools are operated by the Ghana Education Service.

Level two of secondary education includes senior secondary or technical or vocational education provided at senior high schools, technical or vocational institutes, and through apprenticeship programs. Following the 2007 reforms, the number of years for this level was increased to four years, though the number was reverted to three after the 2008 presidential elections. The curriculum at this level is diversified to cater to differences in student aptitudes, abilities, interests, and levels and includes general science, arts, vocational, and technical programs. Under the new education reform, students with high scores on the Basic Education Certificate Examination are admitted into senior high schools, whereas those with average marks enter technical or vocational schools.[11]

In the past eight years, there has been a substantial increase in school enrollment at the basic education level (preschool through junior high school) due to two factors: the elimination of fees in all public schools as of 2005, and the introduction of the school feeding program, which provides meals to children in schools.[12] In the 2004–05 school year, public and private basic schools had a total enrollment of 5,631,767 students; by the 2010–11 school year enrollment increased to 7,028,299, with students enrolled in 4,969 preschools, 18,801 kindergartens, 19,723 primary schools, and 11,709 junior high schools.[13] For kindergarten, the gross enrollment ratio increased from 56.5 percent in 2004–05 to 98.4 percent in 2010–11. During the same period, enrollment ratios similarly increased in primary schools (from 83.3% to 96.4%) and junior high schools (70.2 to 86.3%).[14] The large increase in kindergarten enrollment resulted from the mandatory inclusion of kindergarten in all public primary schools. However, even as enrollments have increased, the national student-teacher ratio for basic school has remained 35:1.[15]

Although policies of the previous and current governments have helped raise the standard of education in the country, the education system still faces a number of challenges. Increases in enrollment at all levels of education imply the need for more classrooms or lecture blocks, more learning materials, and adequately resourced laboratories and libraries. Furthermore, more prepared teachers are needed at all levels in addition to improved 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 current demand, even though this sector receives the bulk of national funds annually. Finally, uses of science and technology for economic advancement have necessitated policy changes, such as introducing information and communication technology as a subject from basic education to the tertiary level; yes this also requires additional resources.

Languages of Instruction

English is the official language of Ghana and predominates in government and business affairs. It also is the standard medium of instruction. About 79 languages are spoken in the country, nine of which have the status of government-sponsored languages: Akan (Ashanti Twi, Fanti, Akuapem Twi, Akyem, Kwahu, and Nzema) Dagaare-Wale, Dagbani, Dangme, Ewe, Ga, Gonja, and Kasem.[16] Ghanaian languages also are studied in schools, depending on the native language of the community in which the school is located. Though not an official language, Hausa is the lingua franca among Ghana's Muslims who comprise about 16 percent of the population. French is increasingly taught in pre-tertiary schools.

The provisional results of the housing and population census showed that Ghana's population, which was 18,800,000 in 2000 and 21,029,853 in 2005, increased further to 24,223,431 in 2010.[17] The population includes major ethnic groups, such as the Akans (49.1%), Ewes (12.7%), Mole-Dagombas (16.5%), Guan (9.8%), and Ga-Adangbe (8%).[18]

Mathematics Curriculum in Primary and Lower Secondary Grades

The goal of the 2007 mathematics curriculum, as designed by the Curriculum Research and Development Division, is to ensure that students are equipped with competencies in the knowledge and application of basic mathematical knowledge and skills.[19]

Beginning in 1998, profile dimensions became central to the mathematics curriculum, and enable teachers to state specific behavioral objectives. The dimensions of knowledge and understanding and the application of knowledge are the prime focuses of mathematics teaching and learning, though these dimensions are weighted differently at the primary (Grades 1–3 and 4–6) and junior secondary (Grades 7–9) levels. The primary school curriculum prescribes that 40 percent of learning time should focus on knowledge and understanding and 60 percent should focus on application. For junior high school, the curriculum prescribes that 30 percent of learning time should focus on knowledge and understanding and 70 percent on application.[20] However, even though more weight is given to application of knowledge in the intended curriculum, implementation varies across classrooms, where much more emphasis is put on knowledge and understanding.

The curriculum is organized according to topics (content) and specific objectives, which define concepts, teaching and learning activities, and evaluation indicators for the teacher. Time allocations for lessons also are stated.

The curriculum for primary and junior high schools is structured to cover the six years of primary education and the three years of junior high school education, respectively, with each year's work divided into units. Based on the 2007 curriculum, the mathematics content areas for primary and junior high school are as follows.

At the primary school level, mathematics instruction emphasizes mathematical knowledge and skills that should help students develop competence in basic numeracy to function effectively in society.[21] The skills taught include the following: using numbers competently, reading and interpreting data, reasoning logically, solving problems involving calculations and mathematical reasoning, and communicating effectively with other people using accurate mathematical data and interpretations. Also, students are required to develop interest in the use of mathematics and the ability to conduct investigations using mathematical ideas. Education in Ghana aims to emphasize the acquisition of these qualities and the importance of functional mathematics in teaching and learning in the school system.[22]

In junior high school, the mathematics curriculum covers 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.[23] Students are expected to acquire the ability to analyze, compare, distinguish, and identify significant points. They also are expected to synthesize, generate, and design new ideas and solutions. Additionally, students are required to evaluate (compare and contrast), discuss (criticize, justify, and support), conclude, and make recommendations.

Science Curriculum in Primary and Lower Secondary Grades

The goal of the science curriculum, as designed by the Curriculum Research and Development Division, is to ensure that students are equipped with competencies in the knowledge and application of basic scientific concepts and skills.

Beginning in 1998, as with mathematics, profile dimensions were made central to the science curriculum; these include knowledge and understanding, application of knowledge, and attitudes and skills are the prime focuses of teaching and learning science, which are weighted differently for primary (Grades 1–3 and 4–6) and junior secondary levels (Grades 7–9).[24] The primary school curriculum prescribes that 40 percent of teaching, learning, and testing should focus on knowledge and understanding, 40 percent on application of knowledge, and 20 percent on attitudes and process skills. For junior high school, the curriculum prescribes that 30 percent of teaching, learning, and testing should focus on knowledge and understanding, 40 percent on application of knowledge, and 30 percent on attitudes and process skills. It is expected that junior high school students have the ability to apply rules, methods, and theories to real-life challenges that are 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 science curriculum is organized similarly to mathematics regarding content, specific objectives, division of work into sections and units, and time allocation for lessons in primary and junior secondary education. In the case of science teaching and learning, the goal is to raise all students' level of scientific literacy and equip them with the relevant basic integrated scientific knowledge needed for their own survival and for the development of the country. It also is expected that scientific experiences in school will cultivate students' interest and love for science and will urge students to seek further studies in science in preparation for scientific careers. Some of the positive attitudes and values students are expected to develop include the following: the spirit of curiosity, creativity, and critical thinking; skills, habits of mind, and attitudes necessary for scientific inquiry; interest in investigating and understanding their environment; the ability to communicate scientific ideas effectively; and proficiency in using scientific concepts to explain their own lives and the world around them.

Based on the 2007 curriculum, the science content areas for primary and junior high school are as follows.[25] In primary school, science is taught as the subject natural science. At the lower primary level (Grades 1–3), content includes the study of plant and animal life, water and other liquids, air, food, soil, and care of the human body. At the upper primary level (Grades 4–6), content includes sound, heat, light, electricity, metals and magnetism, and the sky and heavenly bodies, in addition to topics previously taught at the lower primary level.

The natural science curriculum was designed to equip students with the following basic concepts: phenomena in the environment, the inter-relationship of living things and their surroundings, and appreciation for and the ability to solve simple problems in the environment.[26] Students are expected to develop relevant process skills to guide their exploration of the environment. They are 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 systematic thinking.

In junior high school, science is taught as an integrated subject, and the 2007 curriculum is divided into sections and units. While the number of sections differs from class-to-class, each unit has specific objectives. The major content areas or sections that are to be covered before the end of junior high school are as follows: [27]

- 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; and
- Metals and nonmetals, including alloys, and rusting.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional time for mathematics and science at upper primary (Grades 4–6) consists of nine and six periods per week, respectively, each lasting 30 minutes. In junior high schools, the time allocation for mathematics and integrated science is ten and four periods per week, respectively, with each period lasting 30 and 35 minutes, respectively.

Instructional Materials, Equipment, and Laboratories

The central government and the metropolitan, municipal, and district assemblies provide schools with science and mathematics textbooks, as well as supplementary readers. Private publishers also produce textbooks, which the ministry evaluates and selects 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 encourages individuals, publishers, subject associations, and professional bodies to develop and write textbooks, as well as to produce science, technology, and mathematics educational equipment. Writers are expected to incorporate appropriate problems requiring mathematical and scientific thinking, rather than memorization and recall. There is no policy with respect to laboratories and public basic education schools do not have them. However, some private schools do have laboratories.

Use of Technology

The current information and communication technology (ICT) curriculum, which mandates the teaching of simple concepts and the application of ICT at the basic education level, also includes instruction on the use of computers for teaching and learning. However, only a few basic education schools have access to computers, and most of these are private schools.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Some upper primary classes (Grades 4–6) and junior high schools (Grades 7–9) have specialist mathematics and science teachers. Students in primary Grades 1–3 have generalist teachers.

Homework Policies

It is expected that every teacher will give students assignments after the completion of each lesson. The policy on homework is very clear on the number of assignments by subject per week, and teachers are aware of this policy.

Teachers and Teacher Education

Teacher Education Specific to Mathematics and Science

Teacher education in Ghana is streamlined to cover all four levels of the education system.

Under the 2007 education reforms, teacher colleges became colleges of education. Currently, there are 38 colleges of education in the country. For preschool teachers, a three-month preschool teacher education course leads to a Nursery Teacher's Certificate. Teachers who graduate from three-year programs at these colleges are awarded a Diploma in Basic Education, which enables them to teach at the basic education level. The University of Cape Coast oversees the curriculum and assessment of colleges of education. The Teacher Education Division of the Ghana Education Service has the responsibility of ensuring admissions and employment of prospective teachers and graduates. The minimum entry requirements for three-year teacher education programs in colleges offering science and mathematics as major subjects include the following: 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 technical subject.

To enhance the teaching and learning of mathematics, science, and technology in basic education schools and also to produce adequate numbers of mathematics and science teachers, the ministry has selected 15 colleges of education to specialize in the education of mathematics and science teachers.[28] This intervention recognizes the importance of science and technology to Ghana's development.

However, in primary education (Grades 1–6) general classroom teachers typically teach all subjects and specialized training in mathematics and science is not required. In some upper primary classes (Grades 4–6) and in junior high schools (Grades 7–9), teachers are subject-specific, and specialist mathematics and science education is required to teach these subjects. This policy notwithstanding, there is a general shortage of mathematics and science teachers in Ghana.

Teaching at the secondary level requires a diploma or degree obtained after a two- to four-year program at a polytechnic or university. To teach at tertiary institutions, one should have obtained a master's or a doctoral degree in the subject discipline.

Although most basic education schools in urban centers are equipped with qualified teachers, rural schools often lack teachers, especially in science and mathematics. Incentives, such as accommodation, motorbikes, bicycles, and home appliances, are being provided to motivate teachers to accept positions in rural areas.

Requirements for Ongoing Professional Development

Teachers can improve their professional status through promotion to a higher rank and by taking a leave to study subjects and programs in higher educational institutions approved by the Ghana Education Service. Programs in mathematics and science are promoted. Teachers also are encouraged to take distance education courses at universities after three years of teaching, and some take mathematics and science courses at the bachelor degree level. These distance learning modules have been provided under the Free Compulsory Universal Basic Education policy.[29] Short courses in institutions outside Ghana also are offered to update teachers' skills.[30, 31]

Additionally, to promote good pedagogical practices, schools and district education offices organize teacher professional development and workshops. Topics covered include learning goals and appropriate teaching methods in areas that are identified as particularly weak.

Monitoring Student Progress in Mathematics and Science

Ghana has no high stakes examinations from kindergarten through junior high school. At the end of three-year junior high school (Year 3, or Grade 9), all students take the Basic Education Certificate Examination, which is a national examination. This examination is very important and it determines admission to senior high school.[32]

The West African Secondary School Certificate Examination is another high stakes examination. Formerly a national examination, it now is a regional examination administered by the West African Examinations Council in five English-speaking countries: Ghana, Nigeria, Sierra Leone, Gambia, and Liberia. This examination is taken at the end of the three-year senior high school

(Grade 12) and the results are used for admission into universities, polytechnics, and colleges of education.

In addition to the two high stakes examinations at Grades 9 and 12, a small number of assessment systems are administered periodically to evaluate the curriculum used in schools. These include TIMSS for junior high school, Year 2 (Grade 8) students; the National Education Assessments of numeracy and literacy for primary schools; and school-based assessments used at all levels of pre-tertiary schools. Of these, TIMSS is the only assessment that specifically addresses mathematics and science in Ghana.

Students in Ghana receive grades for the subjects they study and these grades are recorded in report cards at the end of every school term. Report cards are signed by classroom teachers, form teachers, and head teachers for authentication. These report cards monitor student performance as they progress from one grade or class to the next. Students in the third year of junior high school (Grade 9) are assigned grades corresponding to their scores on the Basic Education Certificate Examination.[33]

All students in Ghana are automatically promoted to the next class, irrespective of their performance on tests and this promotion policy is strictly adhered to by all public schools.[34] However, this policy does not apply to private schools, where students are retained when they do not do well at the end of the school year. New educational reforms may revisit this policy because automatic promotion has been determined to lower education standards.

Impact and Use of TIMSS

In 2002, the government embarked upon a comprehensive review of the education system, which was fully implemented in 2007.[35] Key areas of focus were curriculum development and textbook production. The results of TIMSS 2003 and 2007 have informed on-going mathematics and science curriculum reforms and new recommended syllabi are already in place. The new curriculum, which took effect in September 2007, has made the mathematics curriculum for primary education more activity-oriented. Further, the junior high school curriculum has introduced higher cognitive skills, such as synthesis and evaluation, and has reduced the number of major content areas. The mathematics and science curricula used in Ghana when TIMSS 2011 was administered were the curricula from the 2007 reforms.

After Ghana's participation in TIMSS 2003, a country report was made available to the Ministry of Education, the West African Examinations Council, and other stakeholders. As a result of this report, test items used in national and school level assessments of mathematics and science began to change. Emphasis on requiring memorization and recall lessened, while application of acquired mathematical and scientific knowledge increased. In addition, mathematics and science teachers throughout the country received updates on teaching and learning skills based on contemporary methods of teaching and assessment. As part of workshops organized mainly by the TIMSS National Center, in collaboration with the District Education Offices, teachers were taught to write test items that measured application and analysis of mathematical and scientific concepts, in addition to those on recall.

In recent years, the West African Examinations Council has been modifying its mathematics and science examination items using practices learned from TIMSS. Also, aside from school teachers, examiners and chief examiners of the council are scorers and supervisors for TIMSS achievement items, which allows for the sharing of information across assessments.

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Honduras

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Introduction

Overview of the Education System

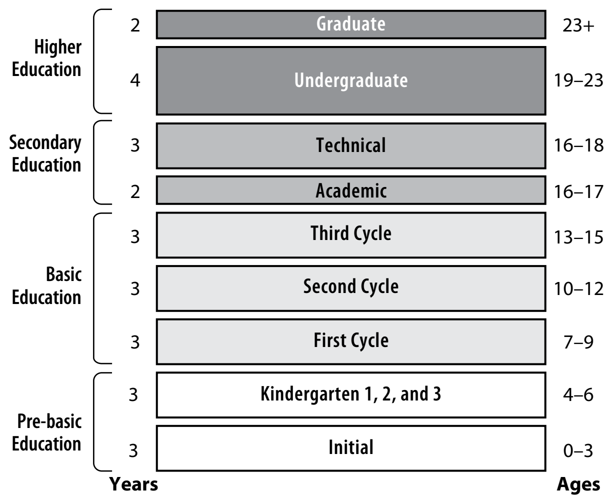
According to the national constitution of the Republic of Honduras,[1] the provision of education is a key federal function. National education is defined as secular and is based on the fundamental principles of democracy and free access to everyone, without any type of discrimination.

The formal education system in Honduras remains highly centralized, despite many previous and current efforts to decentralize.[2] The government of Honduras finances public education, while private schools raise their funds almost exclusively from tuition fees.

The Ministry of Education (*Secretaría de Educación*) is responsible for providing educational services and upholding the education laws through secondary school. The ministry's main activities include the formulation and implementation of the intended curriculum in all subjects, including mathematics and science. With the formulation and approval of the new intended curriculum for basic education in 2003, the ministry collaborated with the international community (bilateral and multilateral partners) to produce and distribute syllabi, standards, textbooks, and teaching guides for all the public schools in the country. In addition, the ministry appoints, transfers, promotes, and dismisses teachers in public schools with the help of its departmental offices and specially appointed commissions, which are constituted by ministry officials and members of the teachers unions. No special funding is provided for the teaching of mathematics or science.

The ministry regulates both formal and informal education sectors in Honduras, though it is primarily in charge of the formal sector (see Exhibit 1). The informal education sector includes several flexible options from short-term courses for specific trades to academic programs that allow students with special needs to complete their formal education in the first three stages of formal education, or to acquire specific skills to enter the labor market.

Exhibit 1: The Structure of the Formal Education System in Honduras



Formal education in Honduras begins with pre-basic education, which is not compulsory. The initial years of pre-basic education, encompassing ages 0–3, is mainly the responsibility of the family. For children ages 4–6, Honduras has numerous Kindergarten programs ranging up to three years in length, though children from poor families frequently attend less than one year. Enrollment rates in Kindergarten programs have gradually increased in the last two decades, due mainly to the growth of non-formal alternatives. Honduras's education system offers nine years of free and compulsory basic education and two or three years of secondary schooling.

Basic education is sub-divided into three cycles: first cycle encompasses Grades 1–3 (ages 7–9); second cycle encompasses Grades 4–6 (ages 10–12); and third cycle encompasses Grades 7–9 (ages 13–15). According to the basic education curriculum, the first cycle initiates the students in the development of instrumental skills; the second cycle continues with the development of instrumental skills; and the third cycle completes the development of instrumental skills, and introduces students to scientific and technological knowledge.[3]

Secondary education is sub-divided into two levels: academic secondary school lasts two years, and is intended for students whose main goal is to continue into higher education; and technical secondary school lasts three years, and is intended for students whose main goal is to enter the labor market. *Escuelas Normales*, or normal schools, are three-year secondary education schools with a special status. These schools prepare teachers to work as basic education teachers for first or second cycle, or to continue at the university level to become third cycle or secondary education teachers.

Tertiary education includes several national universities and an increasing number of private universities, with several undergraduate and graduate options. The cost of tertiary education for parents and students is relatively inexpensive because national universities are heavily subsidized by the government and still cover a higher percentage of the enrollment.

Since 2003 Honduras has benefitted from the Fast Track Initiative for Education for All, primarily sponsored by the World Bank. This initiative is focused on improving conditions to ensure that children have access to and successfully complete basic education.[4] With this special aid, the new curriculum for basic education was designed and approved in 2003. Implementation of the curriculum for all cycles of basic education began in 2004. In addition, new textbooks and teachers' guides have been developed for mathematics, Spanish, and science for the two first levels of basic education.

In January 2012, the Honduran government approved a new General Education Law. This new law is intended to maintain the present structure of the education system and the curriculum, but also to introduce profound changes in the areas of management, teacher education, and assessment of the quality of education. The law will be enacted as of 2012.

At present, Honduras has no special initiatives to encourage students to pursue careers in mathematics or science and technology, despite a shortage of expertise in these areas.

Languages of Instruction

The total population of Honduras is estimated at 8 million: 90 percent are mestizos (mixed Amerindian and European), 7 percent are Amerindian, 2 percent are Black, and 1 percent are White.[5] Although the country was populated by a number of ethnic groups (e.g., Mayas-Chortis, Lencas, Tolupanes, Pech, Tauhacas) before Spanish colonization, most groups have been culturally integrated. Following colonization, some other ethnic groups such as the Garifunas and Misquitos have settled in the north coast of the country.

Spanish is the official language of Honduras, though a number of Amerindian dialects continue to be used in some parts of the country. In addition, English is common in the Bay Islands, and most well-educated people on the mainland understand English. Both the mass media and local press use Spanish as the language of communication.

All instruction and textbooks are in Spanish, and children with a different mother tongue begin learning Spanish when they enter school. Through the implementation of several cultural and ethnic education programs, most Honduran ethnic groups receive education in both their own native language and in Spanish at public schools. An increasing number of private schools in urban areas use English or French as the language of instruction.

Mathematics Curriculum in Primary and Lower Secondary Grades

The basic education curriculum is organized into a number of curricular areas. The first two cycles have five areas: communications (language, arts), mathematics, social sciences, natural sciences, and physical (sports) education. In the third cycle, a technological area is added. In addition, all curricular areas across all cycles incorporate three dimensions, or *ejes transversales*: identity, work, and participatory democracy.

The main goals of the mathematics curriculum in basic education are the following: develop logical thinking, apply mathematical procedures, and facilitate problem solving in different contexts; link mathematics with the activities of daily living; and use the symbolic language of mathematics to express and communicate quantitative and qualitative information in other areas, inside and outside the school, through the use of computers.[6] The mathematics curriculum covered in the fourth grade of basic education is as follows: [7]

- Numbers and Operations—Numbers up to 1,000,000; multiplication where the product is less than 1,000,000; division where the dividend is less than 10,000; fractions; and decimals.
- Geometry—Lines, angles, triangles, quadrilaterals, and geometric solids.
- Measurement—Currency and its use in everyday life, length, time, weight, and capacity measures (e.g., volume).
- Statistics—Data collection, organization, and presentation; and reading bar graphs.

The mathematics curriculum covered in eighth grade is as follows: [8]

- Numbers and Operations—Percent and operations with real numbers.
- Algebra—Operations with polynomials, and rational algebraic expressions.

- Geometry—Triangles and quadrilaterals.
- Statistics—Organization and presentation of data, and measures of central tendency.

Science Curriculum in Primary and Lower Secondary Grades

The main goals of the science curriculum in basic education (Grades 1–9) are the following: gain knowledge about and learn to interpret the world around them; begin to apply the scientific method as the best procedure for acquiring a more precise knowledge of nature; and develop positive attitudes toward the environment, and to become actively involved in preserving and improving it.[9]

The main topics of the science curriculum that are taught in the fourth grade of basic education are as follows: [10]

- Living Beings in their Environment—Nutrition and reproduction of plants and animals, relationships among living things, and life cycles.
- Human Beings and Health—Constitution of the human organism; and anatomy and physiology of the nervous, musculoskeletal, circulatory, respiratory, digestive, and excretory systems.
- Earth and the Universe—Structure and dynamics of the solar system, structure of the Earth, and erosion and its consequences.
- Matter, Energy, and Technology—Manufacturing of products from animals, vegetables, and minerals; and models of school gardens (*huertos*) and parks.

The science curriculum that is covered in the eighth grade of basic education is as follows: [11]

- Living Beings in their Environment—Nutrition, reproductive functions and relations, and ecosystems.
- Human Beings and Health—Nutrition and health, school gardens (*huertos*), and the immune system.
- Earth and the Universe—The hydrosphere and water, the atmosphere, changes in weather and climate, and natural disasters.
- Matter, Energy, and Technology—Energy, heat, and light.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

The Ministry of Education in Honduras mandates two hundred school days per year, though frequent teacher strikes make this difficult to achieve. By law, students in basic education receive instruction through roughly 36 periods each week, with each period lasting approximately 45 minutes. In all Grades 1–9, students are taught five periods of mathematics and the natural sciences per week. With the introduction of the new curriculum, however, school principals have the authority to adapt these time allocations to school needs.[12] Also, instructional time may differ slightly in schools that have fewer than six teachers—as of 2011, at least one third of schools in Honduras had only one or two teachers.

Use of Technology

The new curriculum prescribes the teaching of technology as part of the natural sciences in the first two cycles and as a separate subject in the third cycle of basic education. However, Honduras lags behind most other countries in Central America regarding access to information and communication technology (ICT).[13] Only about 12 percent of Honduran households have access to a computer, and only about 13 percent of the population use the Internet at least once a month.[14, 15] There is no data on the availability of ICT in schools and the government currently lacks a specific plan or strategy to provide schools with computers or laboratories.

To place the use of technology in schools in context, it is important to note that most schools in Honduras are rural and lack access to the most basic services such as water and electricity. Urban schools (especially private schools) are usually well equipped, even with sophisticated ICT. In the last decade, with assistance from international agencies and the private sector, the government has piloted several programs to furnish some schools with either computers, laboratories, or both. However, these isolated efforts have not made a widespread difference with regard to national ICT indicators.

There is some hope for change, however. The present government is now implementing the One Computer per Child Program (*EDUCATRACHOS*) that has seen some success in other Latin American countries.[16] The program is intended to reach all public schools and already has begun to benefit students and teachers from schools in Honduras's poorest villages. While obtaining financial resources will be a challenge, the program could have great long-term impact, if implemented as designed.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Schools have no specialist teachers in the fields of mathematics or science through the sixth grade of basic education. Beginning in cycle three (Grade 7), specialist teachers are required to have degrees in mathematics or science in order to teach those subjects. However, general teachers or non-qualified teachers commonly teach these subjects, especially in rural and some private schools.

Teachers and Teacher Education

Teacher Education Specific to Mathematics and Science

Institutional reform efforts in teacher education in Honduras over the past two decades have failed to achieve an effective or sufficiently large-scale impact on the core of teaching practice in classrooms and schools. Because of this failure, Honduras remains one of the few countries in the world where the professional education of teachers from the first two cycles (Grades 1–6) of basic education is not accomplished at the tertiary education level.[17]

To become a teacher for Grades 1–6, prospective teachers must attend three years of the secondary cycle in normal schools (*Escuelas Normales*). After completing the program they are awarded a teaching certificate (*Maestro de educación primaria*). To teach in the third cycle of basic education (Grades 7–9) or at the secondary level, aspiring teachers must first obtain a secondary education diploma, preferably at a normal school. Then they must complete an undergraduate program at the National Pedagogical University or complete the pedagogy program at the Autonomous National University of Honduras.[18] However, many teachers at the third level of basic education, or even at the secondary education level, commonly do not have a higher education diploma or have not completed an undergraduate program in the subject that they teach.

Honduras has no shortage of students wishing to become basic or secondary education teachers. Since the approval of the new Law for Teachers (*Estatuto del Docente*) in 1997, teachers have had access to relatively better salaries, job stability, and other important social benefits. As a result, an increasing number of students wish to study at the normal schools and at the National Pedagogic University. However, despite the influx of students into the field of education, once these students obtain their diplomas, there is no guarantee that the best will be hired into the education system.

Overall, the weak training of teachers in Honduras is a major impetus for continuing to reform teacher education in the country. Because many teachers receive only a secondary level education, teachers of the first two cycles of basic education frequently lack a solid background in subject matter knowledge and pedagogy, and have only limited practical work experience. Teachers for the third cycle of basic education and secondary education have university or college degrees, and thus would be expected to have more subject matter and pedagogy knowledge. However, even at this level, their practical work experience is poor. In addition, the country has no support or induction mechanism for new teachers. Finally, Honduras's education system lacks a continuous accreditation process for teacher education institutions and programs.

Requirements for Ongoing Professional Development

The Ministry of Education has not created an effective system of professional development of teachers. In the last two decades, the professionalization of in-service teachers has been the responsibility of the National Pedagogic University, primarily through two programs: the Continuous Education Program for Basic Education, and the Special University Education Program for Teachers. While an increasing number of teachers are graduating from both these programs, there is still no evidence of their impact on the quality of education.[19]

The ministry has established the National Institute for Educational Research and Training to oversee professional development of teachers, offering refresher courses not leading to higher degree diplomas. The role of the institute has become more important as a direct result of the introduction of the new and more ambitious 2003 curriculum. However, the institute remains a traditional, centralized, and underfunded institution that is unable to provide all teachers with the skills required to implement the new curriculum and to develop their teaching careers.

Finally, Honduras has no standards for the evaluation of the performance of teachers. Although required by current laws, the ministry and the teacher's unions have not been able to reach agreement on this issue. As a result, teacher career progression and salary increases are based on the number of years of experience and on, often passive, participation in training activities. A criticism of this current practice is that it does not give teachers incentives or encourage them to make any effort to innovate or seek new ways of teaching.

Monitoring Student Progress in Mathematics and Science

Since the mid-1990s, assessing the quality of basic education has been a top priority for the Ministry of Education. As a result, a National System of Evaluation of Academic Achievement (SINECE) has been designed. This system has been operating with an internal unit within the ministry and an external unit called External Unit for the Measurement of Quality of Education that belongs to the National Pedagogic University. However, SINECE does not yet have a legal charter. As of 2012, the Honduran government is discussing the creation of an independent institute to run the national assessment system.

With assistance from the World Bank, the External Unit for the Measurement of the Quality of Education was created at the National Pedagogic University. The unit designs, develops, and administers criterion-referenced standardized assessments to a sample of basic education students, mainly those in Grades 3–6, in mathematics, language, and sometimes science. From 1997–2004, the External Unit for the Measurement of Quality of Education regularly administered assessments to a sample of schools nationally. These were low-stakes assessments, with no consequences for schools, teachers, or students. Their main purpose was to monitor the academic progress of the education system and investigate the factors that affect it. Reports were 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 contained some recommendations for improving performance. Most recently, these assessments have been used to measure the progress of the education system in reaching the achievement goal of Education for All.

In 2004, the US Agency for International Development (USAID) implemented the Honduras Improving Student Achievement Project. The project was designed to improve student achievement through reformed and prioritized standards, an enhanced curriculum, and a systematized, integrated, standards-driven testing system designed to measure student achievement of Education for All goals.[20] The project also aimed to develop new standards for basic education, and other materials such as standardized tests administered by the same teachers every two months. Since 2004, the Improving Student Achievement Project has also sponsored development and administration of standardized tests in mathematics and language for all basic education grades. However, the results of these tests are not technically comparable with the ones produced by the External Unit for the Measurement of the Quality of Education. The integration of all these external efforts and the ones developed by the Ministry of Education into a coherent system of evaluation of the quality of education remains a challenge in Honduras.[21] In addition to TIMSS and PIRLS 2011, Honduras is also participating in the Third Regional Comparative and Explanatory Study that is being conducted by the American Laboratory for Assessment of the Quality of Education of UNESCO. This project will comparatively measure the academic achievement of students in mathematics, language, and science in Grades 3 and 6 of the participating Latin American countries.

At all education levels, teachers monitor the progress of individual students through grades and report cards. At the basic and secondary levels, students receive certificates each term, with marks allocated in each subject. Periodically, parents receive school reports of their child's progress, which are 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. At the end of basic and secondary education, students receive school-leaving certificates that enable them either to study at the next level or to seek employment.

Honduras has no high-stakes tests or national examinations, not even at the end of the secondary school. Because there are no final examinations, the overall grade obtained by the student during the school year determines grade promotion. Entrance examinations to the universities are recent, and are developed and administered by the universities themselves.

The Ministry of Education has recently introduced policies aimed at controlling student dropout rates and problems associated with grade repetition; for example, automatic or flexible promotion is currently in an experimental state. In the third cycle of basic education and in secondary education, students who do not pass a subject usually get a second chance or get help with remedial classes. If they still fail to get promoted in two or more subjects, then they must repeat the whole year. Despite these improvements, a relatively high number of students in the first three grades of the basic education still fail to be promoted.

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Hong Kong SAR

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Introduction

Overview of the Education System

In the Hong Kong Special Administrative Region (SAR) of China, responsibility for the education system is shared. The Hong Kong Education Bureau (EDB) is responsible for formulating policies and introducing legislation on education from the preprimary to the tertiary levels. EDB ensures that quality education is provided for Hong Kong's young people and oversees the effective implementation of educational programs.[1] All schools are registered or provisionally registered under EDB's Education Ordinance (CAP 279), and must observe the bureau's Education Ordinance and the Education Regulations (CAP 279A).[2] EDB also monitors the services provided by the University Grant Committee, the Student Financial Assistance Agency, the Hong Kong Examinations and Assessment Authority, the Hong Kong Council for Accreditation of Academic and Vocational Qualifications, and the Vocational Training Council.

Several other bodies also contribute to the enterprise of education in Hong Kong. The Curriculum Development Council is a freestanding advisory body appointed by the Chief Executive of the Hong Kong SAR to give the government advice on curriculum development for preprimary to secondary schools.[3] The council receives support from the Curriculum Development Institute, a division of EDB that provides professional leadership, coordinates curriculum development collaborations with local and international partners, and supports schools in the implementation of curriculum policies and innovations. In particular, the mathematics and science sections of the institute make decisions about Hong Kong's mathematics and science curricula, based on the broad principles established by the council.

For many years, the education system in Hong Kong followed the 6–5–2–3 structure typical of the British system: six years of primary school (Primary 1–6), five years of secondary school (Secondary 1–5, leading to a certificate examination), two years of pre-university study (Secondary 6–7, leading to an advanced-level examination), and three years of university study. Starting from the 2009–10 academic year, a new 6–3–3–4 structure has been implemented, which is more consistent with the system in place in China and many parts of the world: six years of primary school, three years of junior (lower) secondary school, three years of senior (upper) secondary school, and four years of university study.

Under this new structure, the first nine years of compulsory basic education, starting at Grade 1 (Primary 1), remain unchanged, and students follow the same curriculum from the former structure up to Grade 9 (Secondary 3). However, the old system of streaming from Grade 10 (Secondary 4) onward according to subjects (e.g., arts stream, science stream, and commerce stream) has been abolished. All students now take four core subjects—Chinese Language, English Language, Mathematics, and Liberal Studies—as well as two or three elective subjects chosen from a list that includes twenty senior secondary subjects, a range of applied learning courses covering six areas of studies in the vocational fields, and six other languages. Other learning experiences in the areas of moral and civic education, community service, aesthetic development, physical development, and career-related experiences also are included as part of the senior secondary curriculum.[4] Another important change in the education system is that, starting from 2012, a new Hong Kong Diploma of Secondary Education Examination, given at the end of Grade 12 (Secondary 6), will replace the two public examinations previously given at the end of Grades 11 and 13 (Secondary 5 and 7): the Hong Kong Certificate of Education Examination and the Hong Kong Advanced Level Examination.

Preprimary education, which is not part of compulsory education, includes childcare centers for children from birth to age 3, and kindergarten for children ages 3–6 (K1 to K3).[5] Both are privately operated, with childcare centers being registered with the Social Welfare Department, and kindergartens registered with EDB. The Social Welfare Department and EDB collaborated to develop the *Guide to the Pre-primary Curriculum,* which states that preprimary education should help foster children's all-around development, including physical, intellectual, language, aesthetic, social, and emotional aspects.[6]

In addition to government schools, Hong Kong has several other types of schools, including aided schools, Direct Subsidy Scheme (DSS) schools, local private schools, and international schools (such as those run by the English Schools Foundation). Aided schools are free and funded by the government but run by a sponsoring entity. DSS schools are private schools that receive some government funding. Country-specific international schools teach a syllabus from their own country.

Languages of Instruction

Chinese and English are the official languages of Hong Kong, but Cantonese, a Chinese dialect, is spoken by most of the people in Hong Kong. According to the figures of the 2006 Population By-Census conducted by the Census and Statistics Department, more than 90 percent of the population age 5 and over speak Cantonese as their everyday language.[7] Another 8.1 percent of the people speak other Chinese dialects (4.4%), English (2.8%), and Putonghua (0.9%). The government has adopted a biliterate (Chinese and English) and trilingual (Putonghua, Cantonese, and English) policy for the education system.

There is no specific language of instruction policy at the primary level. Most of the primary schools in Hong Kong use Chinese (Cantonese) as the medium of instruction. At the secondary level, the government issued the *Medium of Instruction Guidance for Secondary Schools* in September 1997.[8] The policy framework included the adoption of Chinese (Cantonese) as the language of instruction for all academic subjects in secondary schools, beginning with the 1998–99 academic year. Secondary schools wishing to use English as the medium of instruction must obtain approval from the government and fulfill three prescribed criteria: students must demonstrate the ability to learn in English; teachers must demonstrate the capability to teach in English; and schools must have adequate support strategies and measures for courses taught in English.

In 2005, in its *Report on Review of Medium of Instruction for Secondary Schools and Secondary Schools Places Allocation,* the government issued recommendations on the medium of instruction policy for secondary schools and then fine-tuned those recommendations in 2009.[9] The fine-tuning arrangements were implemented in the 2010–11 school year at Grade 7 (Secondary 1), progressing each year to a higher grade at junior secondary levels. Secondary schools may introduce different medium of instruction arrangements to enrich the English learning environment to suit the different needs of their students. The aim is to increase students' opportunities to use and to be exposed to English. Secondary schools may adopt English for up to 25 percent of total lesson time (excluding the lesson time for English) across subjects, subject to teacher readiness to teach in English. Alternatively, schools may allocate appropriate lesson time to the teaching of one or two non-language subjects in English. Schools also may opt to teach some or all non-language subjects in English provided that the three prescribed criteria are met.[10]

Mathematics Curriculum in Primary and Lower Secondary Grades

In addition to emphasizing the importance of acquiring subject matter knowledge and skills, the mathematics curriculum at the primary and junior secondary levels aims to help students develop general skills and build up positive attitudes toward mathematics learning. The mathematics curriculum also emphasizes the appropriate use of information technology.[11]

The mathematics curriculum guides, published by the Curriculum Development Council, have clearly set forth the goals of primary and secondary mathematics education.[12, 13] The goals of the primary mathematics curriculum are to do the following:

- Stimulate interest in the learning of mathematics;
- Understand and acquire basic mathematical concepts and computational skills;
- Develop creativity and ability to think, communicate, and solve problems;
- Develop number and spatial sense and the ability to appreciate patterns and structures of number and shapes; and
- Enhance lifelong learning abilities through basic mathematical knowledge.

Five content dimensions are covered at the primary level: Number; Shape and Space; Measures; Data Handling; and Algebra.[14] Algebra is introduced in Grade 5 (Primary 5). Exhibit 1 presents the mathematics topics taught in each content dimension at the primary level.

Exhibit 1: Mathematics Topics Taught at Primary Level, Grades 1–6

Number	Shape and Space	Measures	Data Handling	Algebra*
Whole numbers The nature of numbers Fractions, decimals, and percentages Calculating devices	Lines Angles Directions Two-dimensional shapes Three-dimensional shapes	Money Length Time Weight Perimeter Area Volume Speed	Statistics (e.g., pictograms, bar graphs, etc.)	Algebraic symbols Equations

*Introduced in Grade 5

The goals of the secondary mathematics curriculum are to do the following:

- Enable mathematical conceptualization, inquiry, reasoning, and communication, and use mathematics to formulate and solve problems in everyday life, as well as in mathematical contexts;
- Enable manipulation of numbers, symbols, and other mathematical objects;
- Develop number, symbol, and spatial sense, as well as a sense of measurement, and the capability to appreciate structures and patterns; and
- Develop positive attitudes towards mathematics and the ability to appreciate the aesthetic nature and cultural aspects of mathematics.

At the junior secondary level, the mathematics curriculum further integrates the five content dimensions taught in the primary grades into three main learning areas: Number and Algebra; Measures, Shape, and Space; and Data Handling.[15] Exhibit 2 presents the mathematics topics taught in each content dimension at the junior secondary level.

Exhibit 2: Mathematics Topics Taught at Junior Secondary Level, Grades 7–9

Number and Algebra	Measures, Shape, and Space	Data Handling
Directed numbers and the number line Numerical estimation Approximation and errors Rational and irrational numbers Percentages Rate and ratio Formulating problems with algebraic language Manipulation of simple polynomials Laws of integer exponents Factoring simple polynomials Linear equations in one unknown Linear equations in two unknowns Linear inequalities in one unknown Identities Formulas	Estimation in two-dimensional and three-dimensional figure measurement Areas and volumes Introduction to geometry Pythagorean theorem Trigonometric ratios and using trigonometry Transformation and symmetry Introduction to coordinates Coordinate geometry of straight lines Introduction to deductive geometry Congruence and similarity Angles related to lines and rectilinear figures Quadrilaterals	Introduction to various stages of statistics Construction and interpretation of simple diagrams and graphs Measures of central tendency Introduction to probability

Science Curriculum in Primary and Lower Secondary Grades

The emphasis of science education at the primary and junior secondary levels is to enhance students' scientific thinking through learning activities that involve planning, designing, measuring, observing, evaluating procedures, examining evidence, and analyzing data. As described in *Science Education: Key Learning Area Curriculum Guide (Primary 1–Secondary 3)*, school science education provides learning experiences through which students acquire scientific literacy and develop the necessary scientific knowledge and understanding, processing skills, values, and attitudes for their personal development to help them contribute to a scientific and technological world.[16] More specifically, the curriculum guide states that the goals for science education are to do 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 among 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; and
- Be prepared for further studies or careers in the scientific and technological fields.

At the primary level, science is part of the subject of general studies which integrates the following: science education; personal, social, and humanities education; and technology education. The general studies curriculum design is based on the belief that students' learning experiences should be connected and not compartmentalized so that students can develop a holistic view of themselves as individuals in the community, of their place in the natural world, and of the interaction of human beings with the environment.[17] At the junior secondary level, biology, chemistry, physics, earth science, environmental science, and life science are taught together in an integrated manner in the science subject. Some topics in earth science and environmental science are covered in the subject related to personal, social and humanities education.

The science curriculum is arranged into six strands: Scientific Investigation; Life and Living Things; the Material World; Energy and Change; the Earth and Beyond; and Science, Technology, and Society.[18] Exhibits 3 and 4 present the science topics taught in each strand at the primary and junior secondary levels.

Exhibit 3: Science Topics Taught at Primary Level, Grades 1–6

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 throughout 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 everyday life Life and technology Population Problems in the world (e.g., famine, war, and poverty) (This strand is applied to most of the science topics in the science curriculum.)

Exhibit 4: Science Topics Taught at Junior Secondary Level, Grades 7–9

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) Effects of acid rain on the environment Pollution Acids and alkalis (This strand is applied to most of the science topics in the science curriculum.)

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

The Education Bureau makes recommendations for the allocation of instruction time for different subjects.[19] The suggested percentage of time allocated for mathematics education is 12–15 percent of the total instruction time at both the primary and junior secondary levels. The time allocated for general studies at the primary level is 12–15 percent of the total instruction time. For science education at junior secondary level, the suggested allocation is 10–15 percent.

Instructional Materials, Equipment, and Laboratories

There are no mandated instructional materials for mathematics and science in Hong Kong. EDB encourages the use of diverse teaching and learning resources to enhance learning. Materials that provide students with experiences of the world beyond the school and help them develop abstract ideas and concepts are particularly useful for facilitating independent learning.

EDB has lists of recommended textbooks and teaching and learning materials for different subjects in different grades.[20] These textbooks and materials have been vetted by the appropriate reviewing panels of the Textbook Committee at EDB and are considered acceptable in terms of coverage, content, sequence, exercises, language, illustration, and format. Schools are not required to refer to EDB's recommendations when selecting textbooks, teaching and learning materials, or resource packages; but in reality, nearly all local schools rely on these lists. EDB also encourages teachers to use school-based teaching and learning materials, as well as to exercise their professional judgment in preparing and choosing materials that are appropriate to the educational needs and abilities of their students.

In Hong Kong, most primary schools do not have science laboratories, but an increasing number of them have a designated room for conducting science-related activities. All secondary schools have science laboratories appropriate to the demands of the curriculum. In the junior secondary science curriculum, laboratory safety, laboratory equipment, and conducting experiments are introduced at Grade 7 in the strand of scientific investigation. Students practice the use of various equipment and conduct practical activities in the science topics covered in the three years of junior secondary education.

Use of Technology

The *Basic Education Curriculum Guide: Building on Strengths (Primary 1–Secondary 3)*, published by the Curriculum Development Council, states that "information technology for interactive learning" is one of the four key learning tasks that should be emphasized in whole-school curriculum planning.[21] The rationale is that information and communications technology (ICT) helps build the competencies needed for gaining access to information, processing it effectively, and developing closer interactions with different people in different parts of the world.

EDB recognizes that technological tools such as computers and calculators have profoundly changed the world of mathematics education. Students need to master ICT to adapt to the dynamically changing environment. With the help of ICT, certain topics, tools, and drills are obsolete and no longer essential or relevant in mathematics learning.[22] However, teachers should incorporate ICT wisely and critically in mathematics education, avoiding aimless and excessive use. In science education, ICT enhances the development of students' scientific thinking, creativity, and problem-solving skills. However, teachers should provide students with sufficient opportunities for hands-on experiments to develop their science process skills.[23]

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Although not all teachers are formally trained in the subject they are currently teaching, specialist teachers usually teach mathematics and science at the secondary school level, and sometimes at the primary school level as well.

Homework Policies

Hong Kong has no official policies regarding the scope or the amount of homework that schools must assign. As a result, homework practices differ from school to school. EDB gives schools the flexibility to design homework assignments suited to the goals of the curriculum and the needs of their students, and the bureau encourages schools to devise an overall homework policy in consultation with teachers, parents, guidance counselors, and social workers (where appropriate). The basic education curriculum guide includes recommendations for designing meaningful homework assignments and providing homework guidance and feedback.[24] The guide also gives suggestions on the frequency and amount of homework for primary and secondary schools students. EDB believes that an appropriate amount of homework can inspire and motivate students. Homework should not overburden students, cause fatigue, or be used as a punishment. Different subject-specific curriculum guides give homework guidelines specifically designed for the target subjects.

Teachers and Teacher Education

Anyone who wishes to teach in a school must be registered under EDB's Education Ordinance as either a registered teacher or a permitted teacher. Registered teachers possess the approved teaching qualifications and teaching experience as stated in the ordinance. Permitted teachers hold academic qualifications but no teacher training or teacher qualification, and they are given a permit to teach a specified subject or subjects in specified schools.[25]

In Hong Kong, there are two main types of teacher education programs: four-year undergraduate bachelor of education programs and one-year full-time (or two-year part-time) post-graduate diploma in education programs. Five institutions offer teacher education, although only four of these are considered major providers. Because the government does not stipulate the amount of pedagogical training in these programs, there is variation from institution to institution. These institutions also provide specialized teacher education programs in the areas of mathematics education and science education.

It is the government's long-term policy to require all new teachers, including mathematics and science teachers, to receive professional training and hold a degree. All sub-degree, pre-service teacher education programs for primary and secondary school teachers have been upgraded to degree-granting programs; as of the 2004–05 academic year, all graduates of these programs are degree holders.[26] According to the *Hong Kong Annual Digest of Statistics,* the percentage of primary school teachers who are degree holders increased from 80.4 percent in the 2006–07 academic year to 92.5 percent in the 2010–11 academic year.[27] The percentage of secondary school teachers who are degree holders increased from 94.2 percent to 97.5 percent during these four years. In the 2010–11 academic year, 95.7 percent of primary school teachers and 94.4 percent of secondary school teachers were professionally trained.

Requirements for Ongoing Professional Development

EDB, universities, and other professional organizations in Hong Kong offer a variety of professional development programs and other continuing education opportunities for in-service teachers and heads of school to address changes in the curriculum and the ongoing demands of school.[28] The two major types of professional development programs are courses on enhancing the overall professional knowledge of teachers and courses related to key learning areas or subject-specific areas (including mathematics and science).[29] A range of collaborative research and development projects related to key curriculum changes also are conducted in partnership with schools and consultants or universities. Although EDB does not have official requirements for teachers to participate in professional development activities, its Advisory Committee on Teacher Education and Qualifications has set a target of 150 hours of professional development over a three-year period.[30] In addition, some schools may advise their teachers to attend a certain number of professional development courses in each academic year.

Monitoring Student Progress in Mathematics and Science

EDB recommends the use of diverse assessment methods to collect information on student learning. Moreover, assessments should be ongoing as well as both formative and summative. Some common assessment activities in mathematics include the following: classroom discussion and oral presentations; observation of student performance in class; classwork, homework, and project work; and short quizzes, tests, and examinations.[31] Similar assessment activities are used to monitor student progress in science, including paper and pencil tests, written assignments, oral questioning, observation, practical assessment, project work, and portfolios.[32] Nevertheless, tests and examinations are still the most widely used means to inform teachers about what students have learned in mathematics and science.

Impact and Use of TIMSS

The publication and dissemination of Hong Kong students' results from earlier cycles of TIMSS have impacted Hong Kong's mathematics and science education community, as well as the curriculum development process. For example, prompted by earlier cycles of the assessment, the Education Department (which later became the Education Bureau) commissioned the TIMSS national research coordinator to lead a team of researchers to draw implications from TIMSS and other international assessments for mathematic curriculum development in Hong Kong. The research directly informed a new mathematics curriculum issued in 1999. For junior science, two research projects were commissioned by EBD in 2005 and 2010 respectively for identification of areas of improvement through tracking the performance of our student in TIMSS from the 1990s to 2000s. The findings provided invaluable insights on the design of the subsequent professional development programs in enhancing the quality of learning and teaching as well as assessment skills of science teachers. It also provided timely data for curriculum developers to evaluate some major curriculum changes in science education in Hong Kong since 2000.

On the international front, there is keen attention in the education community and beyond focused on the high mathematics and science achievement of East Asian students in general and Hong Kong students in particular. A number of papers on this phenomenon have been published in international journals, and the TIMSS Hong Kong national research coordinator has been invited to deliver papers at major national, regional, and international conferences. In addition, a number of master's and doctoral students have written theses and dissertations based on TIMSS data.

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Hungary

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Introduction

Overview of the Education System

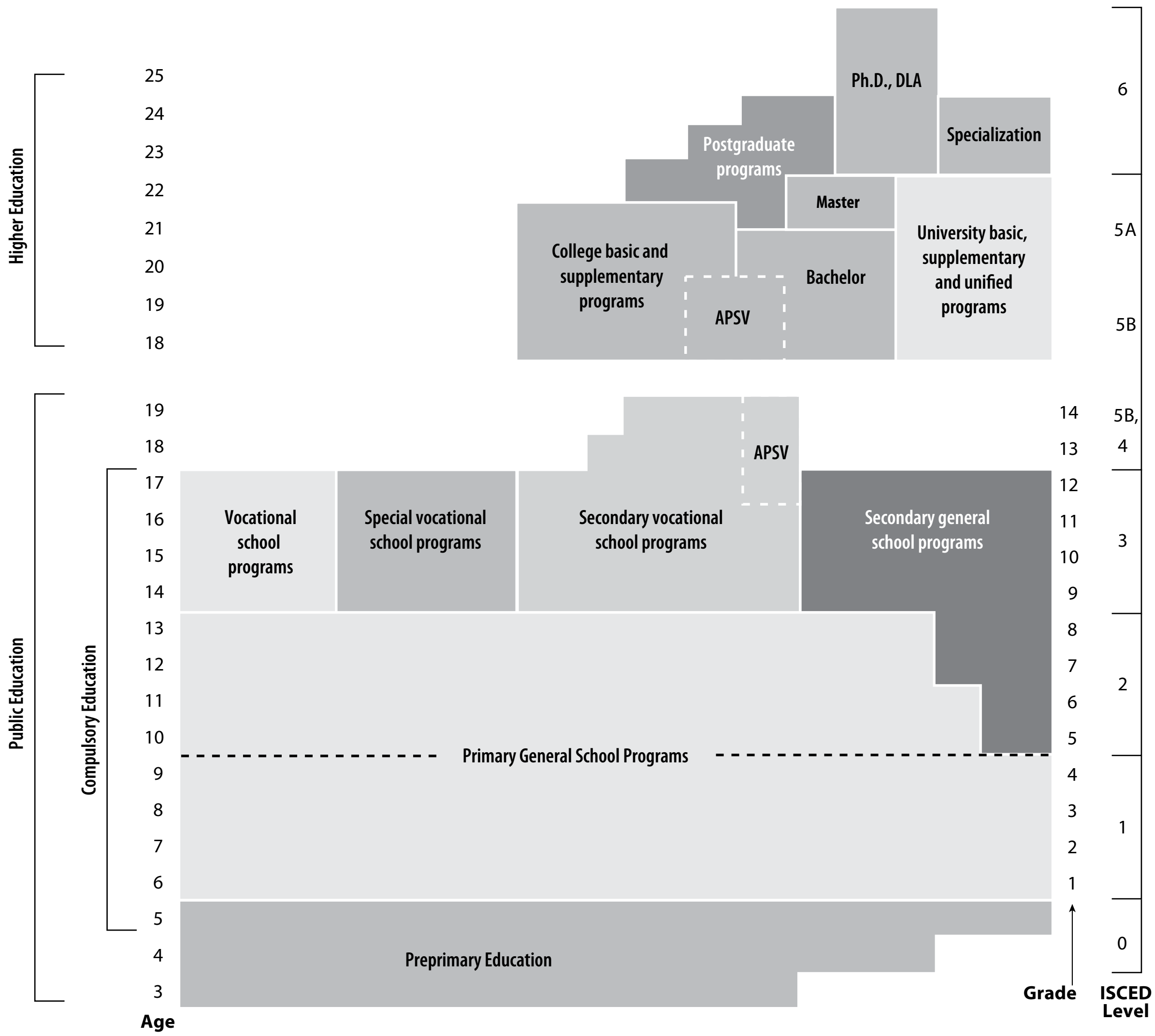
In Hungary, the Public Education Act LXXXIX of 1993 specifies who can open and operate institutes of public education.[1] Included are the following: state, regional, and national minority self-governments; registered religious legal entities; nationally founded economic organizations; foundations; fellowships; and native-born individuals.

The largest organizer of schools in Hungary is the government itself, and most federally-operated schools and student residence facilities are maintained by local governments. Some special vocational training institutions (e.g., police, military) are operated by ministries or nationally budgeted organizations. Religious institutions maintain another substantial proportion of schools. Foundation schools, or private non-denominational schools, comprise the smallest group.

The Hungarian government finances the public education system and the institutions related to it. The Ministry of Education distributes the primary source of this funding through a monthly subsidy to those responsible for school management. Each school's subsidy is based on the number of children attending the school, and the organization responsible for administering the school pays the remaining operational costs. Religious institutions may obtain additional government financing if they perform duties in the public education system.[2]

From 1998 to 2011, education in Hungary was compulsory for children up to age 18. As of the 2012–13 school year, education will be compulsory to age 16, according to the new Public Education Act. Education consists of three levels: preprimary, primary, and secondary. Exhibit 1 presents the typical age and length of full-time education programs in Hungary. Preprimary, primary and secondary school programs (both general and vocational) also include programs for pupils with special educational needs.

Exhibit 1: The Structure of the Hungarian Public Education and Higher Education System by Age, Grade, and ISCED Level



APSV = Accredited post-secondary vocational school.

Practically all children ages 5–14 attend preprimary or primary general school programs, with an enrollment rate of 98.9 percent in 2009.[3] Although children are generally enrolled in preprimary education at age three, enrollment is mandatory at age five. Preprimary education includes character development, preparation for integration into the community, differentiated development for socially disadvantaged children, guidelines for a healthy lifestyle, emotional education, and overall development of skills and competencies. Instructors are required to have a bachelor's degree. The educational program for Kindergarten is published by the Ministry of Education and contains preprimary educational goals and tasks, as well as pedagogical methods.

Primary education is mandatory for eight years and is free. The Public Education Act divides these eight grades into four two-year phases: introductory (Grades 1–2), beginner (Grades 3–4), basic (Grades 5–6), and developmental (Grades 7–8). Although primary school does not have a leaving examination, secondary general schools and secondary vocational schools have the choice to require written entrance exams in mathematics and language arts. Schools without entrance exams must administer the test booklets developed and published by the ministry.

Secondary education features three types of schools: general, vocational, and secondary vocational schools. General schools have a program lasting four years. These schools teach basic subjects with a concentration on those included in the final leaving exam and pursued in tertiary studies, while simultaneously preparing students to enter the workforce. The two-level (intermediate and advanced) final exam determines eligibility for entrance to tertiary studies. About two-thirds of these schools include Grades 9–12, but the number of schools that enroll students for six or eight years is increasing. Students can enter these schools after the fourth or sixth grade of primary school.

Vocational schools also have a four-year program. These schools devote up to 40 percent of instruction at Grades 9 and 10 to career-oriented and vocational training, in addition to the basic subjects. Later grades prepare students for vocational examinations listed in the National Vocational Qualification List; however, students leaving this school type do not take a final leaving examination (*matura*) and cannot advance to tertiary education without additional study. Special vocational programs also are available for students with special educational needs at ISCED levels 2 and 3. These vocational programs do not require a final leaving exam.

Secondary vocational schools have programs ranging from five to seven years. These schools feature characteristics of both general and vocational schools. Students spend the first four years studying basic subjects and gaining the knowledge necessary for later training. At the end of the fourth year, students take the final leaving examination; upon passing the exam, students can go to college or university, or spend the next one to three years preparing for a technical exam in their chosen profession.

Some general and vocational secondary schools offer a preparatory first year in which students focus on foreign language learning, supplemented with some mother tongue and mathematics lessons, before starting the actual four-year program. In 2010, 25 percent of students studied in vocational schools and 75 percent studied in general schools or secondary vocational schools.

Tertiary education consists of colleges, university, and unified programs. Bachelor and master's programs follow the Bologna Process.[4] Postgraduate specialization programs at the ISCED 5A level require graduation from college or university with special attainments. These programs do not bestow a higher attainment level, but give a special qualification.

In the summer of 2010, the newly elected government started a large-scale conceptualization and codification process to write a completely new educational law to replace the Public Education Act LXXXIX of 1993. This new act will likely initiate significant changes in the educational system.

Languages of Instruction

In Hungary, Hungarian is the official language as well as the language of instruction. However, some minorities, such as Croatians, Germans, Romanians, Serbs, Slovaks, and Slovenes, have their own educational institutions within the system. In 2010, 4.6 percent of students attended minority-operated mother tongue, bilingual, or language-teaching schools and kindergartens.

Since 1999, additional minority education classes have been organized when requested by at least eight parents of the same minority group in a community with a non-Hungarian mother tongue. If the number of children is insufficient, parents may request that the local government organize mother tongue and culture classes in connection with school education. These classes are operated as a department of the school or as a separate language school; alternatively, traveling teachers may be hired. Since 2004, classes have been offered in Bulgarian, Greek, Polish, Armenian, Ruthenian, and Ukrainian. The largest minority in Hungary is the Roma community; their institutions of cultural education cater to 3.8 percent of children.[5]

Mathematics Curriculum in Primary and Lower Secondary Grades

The primary function of the National Core Curriculum (NCC) is to define the principles and approaches that govern the content of public education. Allowing for the autonomy of individual schools, the NCC defines the general objectives of public education to be pursued nationwide, the main domains and content phases that public education must cover, and the development tasks that must be fulfilled in the various phases. The NCC is the foundation for the body of knowledge to be acquired in school and thus creates unity in public education.

The principles, goals, and tasks formulated in the National Core Curriculum are organized into documents that are adjusted to reflect local institutional characteristics and individual learning paths. The institutions that write these documents or the organizations that approve them are responsible for making sure that they reflect the values embraced by the NCC. The Framework Curricula and Educational Programs convey the norms established by the NCC in more detail. Together with the NCC, these programs serve as guidelines for the authors and editors of textbooks, the designers of teaching aids and tools, the developers of state examination requirements and national measurement and assessment tools, and in particular, the school teaching staff that prepares and compiles the local curricula.[6]

The main mathematics requirements for students in Grades 4 and 8 are summarized according to the Framework Curricula used by the majority of schools.[7] Mathematics topics for students at Grade 4 are presented in Exhibit 2.

Exhibit 2: Summary of Mathematics Topics, Grade 4

Main Topic	Sub-topics
Arithmetic and Algebra	Natural numbers up to 10,000 (approximate and exact locations on the number line; ordering numbers; estimating quantities with whole numbers; place value; rounding to the nearest ten, hundred, and thousand; order of magnitude; relationships between numbers, multiples, and factors; and sums, differences, products and quotients); fractions (representing equal parts of a whole; reduction to lowest terms; ordering fractions; and equivalent fractions); negative numbers as signed quantities or deficits; numerical operations (interpretation and execution); computations with natural numbers (properties of operations: commutativity, associativity, and relationships between operations; estimating the outcomes of operations; order of operations; and use of brackets); algorithms (thinking algorithmically, describing and following algorithms); and solving number sentences for unknowns.
Word Problems and Problem Solving	Interpreting word problems and real-world problems; and creating mathematical models to describe a word problem, solving the problem, and interpreting the results in context.
Geometry and Measurement	Properties of two- and three-dimensional geometrical shapes; angles; classifying two- or three-dimensional shapes by properties; parallel and perpendicular lines; constructions using a compass and ruler; transformations; visual concepts of congruence and similarity; copying two-dimensional shapes; translation, reflection, and rotation; recognizing and extending geometrical patterns; orienting an object on a line, in a plane, or in space by following instructions or maps; and measurement (knowledge and use of units of length, mass, volume, and time; conversion of units related to measurement; measurements and calculations of perimeter and area; and estimation of area, length, and volume).

Main Topic	Sub-topics
Statistics, Probability, and Combinatorics	Collecting, organizing, and displaying data in bar charts, tables, and graphs; reading data from bar charts, tables, and graphs; interpretation and use of mean and average; determining the frequency of events via experiment; generating, identifying, and counting favorable outcomes; understanding the meaning of and differentiating among certain, possible, and impossible events; probability games, experiments, and observations; and combinations.

Mathematics topics for students at Grade 8 are presented in Exhibit 3.

Exhibit 3: Summary of Mathematics Topics, Grade 8

Main Topic	Sub-topics
Arithmetic and Algebra	Natural numbers in the range of millions; whole numbers, fractions, decimals, and negative numbers; absolute value; reciprocals; rational numbers; relationships among natural, whole, and rational numbers; decimals; binary numbers; approximating, estimating, and checking; operations with rational numbers, properties of operations, and order of operations; finding and using multiples and factors; identifying prime numbers and prime factorizations; positive integer exponentiation; divisibility rules; greatest common divisor and least common multiple; the concept of percent (amount, base, and rate) and solving problems involving percent; simplifying and comparing algebraic expressions; simple operations with algebraic expressions and substitution into algebraic expressions; and linear equations and inequalities.
Relations, Functions, and Sequences	The number line and representations of intervals; using tables or graphs of ordered pairs with linear relationships to find missing coordinates; representation of relationships between sets of numbers; the Cartesian plane and functions and representation of functions in the Cartesian plane; linear functions; examples of non-linear functions; solving linear equations graphically; and arithmetic and geometric sequences.
Geometry and Measurement	Parallelism, perpendicularity, and concavity; line reflection, point reflection, translation, and scale-change; symmetrical shapes; vectors and vector addition; elementary properties of quadrilaterals and triangles; special quadrilaterals and triangles; area and perimeter of rectangles, squares, trapezoids, triangles, and circles; congruent triangles, altitude of a triangle; relationships between angles forming a straight angle and angles in geometric figures; net, volume, and surface area of cubes, prisms, and cylinders; geometric constructions (parallel lines, perpendicular lines, copying angles, perpendicular bisector of a line segment, angle bisector, and triangles); and the Pythagorean theorem.
Probability and Statistics	Concept of probability; probability games and experiments; differentiating between certain and impossible events; estimating probability; frequency, relative frequency, and properties of frequency; mode and extreme values of data; collecting, organizing, and analyzing data sets (mean, median, and mode); displaying and interpreting data; constructing bar graphs, pie charts, and scatter plots; and interpreting, reading, displaying, and analyzing simple graphs.

Science Curriculum in Primary and Lower Secondary Grades

In Grade 4, science is taught as an integrated natural science subject, while in Grade 8, the curriculum is separated into studies of Physics, Chemistry, Biology, and Earth and Environment. The integrated natural science topics for Grade 4 students are presented in Exhibit 4.

Exhibit 4: Summary of Integrated Natural Science Topics, Grade 4

Main Topic	Sub-topics
Methods of Cognition	Investigate, understand, and describe ideas about commonly experienced natural phenomena and discern simple relationships; identify materials and organisms by action and experience; observe, compare and classify non-living and living things; communicate and interpret personal experiences of scientific phenomena; carry out simple experiments and track processes under investigation; and become acquainted with sources of information and their uses.
Basics of Inanimate Nature	Observe and measure properties (color, shape, temperature, surface, hardness, flexibility, taste, and smell) of different materials; identify and observe the most common changes of materials and the environment (dissolving, melting, burning, weather changes, times of the day, seasons, temperature and states of matter); learn about the effect of pollution on the environment; identify the most common pollutants of soil, water, and air and recognize existing dangerous conditions; classify materials according to their properties, uses, and effects; learn about types of food; carry out investigations with magnets and interpret the results; differentiate between flammable and non-flammable materials; and acquire knowledge about combustion.
Maps and Mapping	Distinguish among and represent the most important surface features and water forms on Earth and identify them on a map; and acquire knowledge about the points on a compass and their relationship to one another.
Basics of Animate Nature	Observe plants and animals in the local environment; care for plants; observe and identify those environmental conditions vital for animals and plants; learn about the effects of environmental change and the seasonal changes of flora; distinguish among wild, bred, and grown living things and between animate and inanimate nature; understand the relationships and interdependencies between animals and plants; describe the habitats of living things and the effect humans have on these habitats; and learn about the conservation and protection of nature.
The Human Body and its Functions	Identify important functions of the human body (motion, digestion, and respiration); learn about common illnesses, proper personal hygiene, and a healthy lifestyle; acquire knowledge about health-damaging habits; identify the parts of the body and describe their functions; and identify the most common and harmful effects of the environment on the human body (e.g., sunrays, heat, pollution, parasites).

The science topics for each subject taught in Grade 8 are described in Exhibit 5.

Exhibit 5: Summary of Science Topics, Grade 8

Subject	Main Topic	Sub-topics
Physics	**Motion**	Understand the main concepts of linear motion (reference frames, velocity, and inertia) and accelerated linear motion; learn, understand, and calculate average and instantaneous speed and acceleration; investigate and observe the properties of free fall, carry out experiments, and interpret data; understand and work with the concepts of mass and density; observe and explain changes in motion; understand and apply the concept and representations of force and investigate, and observe the effect of two forces acting on the same object and the equilibrium of forces; understand action and reaction, interactions, momentum, and the concept of conservation of momentum; differentiate among different types of forces and investigate and observe their effects; understand the phenomena of gravity and planetary motion; understand the relationship between Earth's gravity and weight; and acquire knowledge about friction and resistance.
	Energy, Work, and Heat	Investigate and identify types of energy; understand the concept of thermal interaction; investigate and work with heat, heat capacity, and heat of combustion; understand and describe changes in states of matter and energy changes during state changes; understand the idea of conservation of energy, and work with the concepts of power and energy conversion efficiency.
	Electricity	Understand, measure, and work with the concepts of electric current and voltage; investigate and observe the properties of electrical interaction; learn about electric insulators and conductors; learn about sources of electric current and work with electric circuits; understand the concept of electrical resistance and Ohm's law; work with connections in circuits; identify and observe the effects of electric current; understand and calculate the concepts of work and power in the context of electricity; and investigate and describe electromagnetism, electromagnetic induction, and alternating current.
Chemistry	**Basic Concepts, Relationships, and Laws in Chemistry**	Classify matter according to its components (element, compound, mixture, and solution); acquire knowledge about particles in chemistry (atoms, ions, and molecules); acquire knowledge about the atom and understand its composition, different models, and subatomic particles; identify and apply chemical symbols, the periodic table, and chemical formulas; differentiate between physical and chemical changes, as well as among different reaction types; work with chemical equations; understand and apply the law of conservation of mass; work with solutions and calculate their concentrations; learn about the occurrence, preparation, production, and use of common chemicals; acquire knowledge about the typical reactions among substances, carry out experiments, and observe their physiological and environmental effects; and learn about and distinguish between metallic and non-metallic elements and their compounds.

Subject	Main Topic	Sub-topics
Chemistry	**Applications of Matter**	Identify matter and applications of materials important in everyday life; describe the composition of air and water and their most common pollutants; interpret food as a raw material and energy source; learn about household chemicals, metal alloys, corrosion, and the prevention of corrosion; describe some inorganic chemical processes including metallurgy, sulfuric acid production, and glass production.
Biology and Hygiene	**Ecosystems and Biomes**	Describe the food chains of different ecosystems; and identify and explain the effects of pollution on living things and food chains.
	Human Body and Health	Identify the parts of the human body and describe organ systems (sensory, skeletal, muscular, digestive, respiratory, circulatory, excretory, reproductive, and endocrine) and fibers; acquire knowledge about illnesses of organ systems and the characteristics of human body cells; and describe the phases of human growth and development and common health problems.
Earth and Environment	**Our Earth and the Environment**	Describe the Earth's formation, shape, and movements as an astronomical object; describe Earth's cosmic environment, the composition of the solar system, and its connections to the Earth (e.g., solar and lunar eclipses, tides); explain the formation of galaxies and stars and their development; and acquire knowledge about artificial satellites and space research.
	Basics of Geology	Identify and describe the materials that the Earth is composed of; explain the formation of minerals and rocks and the appearance of fossil remains; describe the formation and structure of the Earth, including plate tectonics, basins, continents, mountains, earthquakes, and the development of volcanoes; and acquire knowledge about the Earth's history.
	The Hydrosphere	Distinguish among mainland water, oceans, and seas; and describe water management and protection.
	The Atmosphere	Describe the composition, structure, and basic processes of the atmosphere; explain the effects of air currents on the weather and climate; and describe the phenomena of global warming, the greenhouse effect, and climate change.
	Formation of the Geosphere	Describe the natural processes that transform landmasses and identify the effects of human activity on them.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Materials, Equipment, and Laboratories

Textbooks, exercise books, and teacher's editions of textbooks are the main instructional materials for teaching mathematics and science, both for integrated science courses in Grades 1–6 and for the separate subject areas in Grades 7–8. According to the Public Education Act, teachers can choose textbooks and other instructional materials to correspond with their local curriculum, selecting from a range of texts accredited by the Educational Authority, an institute of the Ministry of Education.

Science teaching and learning in the lower primary school (Grades 1–4) is carried out in the classroom. Generally, a special science room or laboratory is not provided at this level. In recent years, the proportion of schools with science laboratories for upper secondary education has reached 90 percent, though many schools still have older laboratories and equipment. The need for these teaching aids has been recognized, however. As a result, a number of projects were started recently throughout the country to supply schools with laboratories and equipment for teaching science.

Use of Technology

The National Core Curriculum outlines "using vehicles of knowledge" related to mathematics as one of the task areas developed throughout compulsory education. Specifically, the curriculum mentions calculators as well as familiarity with, and sensible and interactive use of, teaching-learning technologies (e.g., Internet, CDs).[8]

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

In primary schools, one teacher is responsible for teaching all subjects to a single cohort of students (known as a class) from first through fourth grade, although many schools have specialist teachers for mathematics, science, and other subjects. By fifth grade, students must have specialist teachers for mathematics and science and often have them for other subjects (e.g., Hungarian literature and grammar).

Homework Policies

Homework policies are determined locally. An acceptable homework policy accounts for the daily learning capacity of students with average abilities and average preparedness, the weekly schedule of school instruction, and leisure time. Local policies must coordinate the quantity and distribution of more demanding written tests, which can be given on specific school days, especially on the first school day of the week.[9]

Teachers and Teacher Education

Before the Bologna Process[10] was adopted in Hungary in 2006, teacher training colleges provided an eight-semester program, that certified teachers to teach all subjects in Grades 1–4 and the subject of their specialization in Grades 5–6. Teacher training in colleges consisted of two mandatory, parallel sets of courses: education in an area of specialization, and general teacher training. General teacher training consisted of coursework in pedagogy and psychology. The main topics in pedagogy included basic theories of pedagogy, theoretical and practical preparation for educational tasks, and skill development in planning, organizing, directing, and assessing teaching and learning. Training in psychology included psychology and interdisciplinary studies, and development of the personality of the teacher trainee. Students attending these courses also took part in professional practice, which included two types of teaching experience: observing and teaching lessons with the guidance of a mentor teacher, and individual teaching practice at a school of choice.

Following the adoption of the Bologna Process in 2006, lower primary teachers are now required to have a bachelor's degree, which can be earned in eight semesters at teacher training colleges that are independent institutions or parts of universities. During current teacher education in Hungary, students take courses in their specialty subjects as well as in pedagogy, and develop their teaching skills. In the last semester students participate in a continuous 8–10 week teaching practice. Teacher education ends with an in-classroom teaching examination and a state examination. Teachers who have earned a bachelor's degree can teach all subjects in Grades 1–4 but teach only the subject of their specialization in Grades 5–6.

Teaching any subject at the upper-elementary level requires a master's degree. Following completion of a six-semester bachelor's degree, training at the master's level focuses on pedagogical areas. Students receive training in methodology (subject pedagogy), general pedagogy, and psychology. In their final semester, students take part in a continuous teaching practice in an institution of their choice that involves observing, individual teaching, dealing with after-school tasks, and attending related seminars. Teacher qualification at the master's level allows teaching in Grades 5–12.[11]

Requirements for Ongoing Professional Development

Teachers are required to participate in at least 120 hours of professional development every seven years.

School principals have the choice to reduce teachers' workload if teachers are currently involved in in-service training programs. Furthermore, the employer may cover the total cost of professional development. Generally, schools cover 80 percent of professional development costs; coverage of the additional costs (e.g., travel, accommodations) can vary.

Subject exam preparatory courses are the most common form of professional development. These classes usually cover education management, pedagogy, and professional services. However, assessment and evaluation courses are becoming increasingly popular. After completing a subject exam preparatory course, teachers advance a step on the pay scale, can request inclusion in the national listing of experts, and can undertake specialized public education tasks.[12]

Monitoring Student Progress in Mathematics and Science

Since the 2001–02 academic year, Hungary has administered its National Assessment of Basic Competencies (NABC) nine times to examine student performance in mathematics and reading. Since 2004, all students in Grades 6, 8, and 10 have taken part in the testing. The assessment measures students' ability to use their skills and knowledge to solve problems modelling everyday situations, and does not focus on textbook knowledge. The NABC provides benchmarks for student performance in seven levels of competency. School level results are published on a public website nine months after the assessment, while schools and the organizations responsible for them receive additional data-analysis software that enables them to study student performance in more detail. Since 2008, the implementation of assessment IDs has made it possible to track individual student development from Grade 6 through Grade 10.[13]

Parallel to NABC, testing fourth-grade students' basic reading, math, problem-solving, and writing skills began during the 2005–06 academic year. The Public Education Act guarantees the annual administration of these tests and requires schools to monitor their performance as part of their quality-control programs.

To reduce disadvantages caused when children develop at different rates, the mandatory testing of first-grade students' basic competencies began during the 2006–07 academic year. The Ministry of Education provides all educational institutions with a free evaluation kit, called the *Diagnostic Development System*. This evaluation kit measures student social development and skills, elementary arithmetic, fine motor coordination for writing, and comprehension of and vocabulary for relationships. At the beginning of the 2009–10 academic year, 31.4 percent of first grade students were evaluated with this assessment.

In addition to assessments, student performance and progress are regularly evaluated through grades. Teachers use interim grades as the basis for mid-term and end-of-term grades. The class teacher notes a grade for student conduct and diligence after consulting with other teachers who also work with that student. In upper primary and secondary schools, grades range from excellent (5) to insufficient (1). In evaluations of conduct and diligence, grades range from exemplary (5) to poor (2).

Schools inform parents about student performance on a regular basis. Students keep their grades and school notices in a notebook that their parents and class teachers sign every month. Additionally, the school sends notices to parents at mid-term and the end of the school year. In Grades 1–3 and midterm in Grade 4, teachers present a written evaluation of student progress, describing it as excellent, good, or adequate and noting if the student requires tutoring. Teachers also must give a detailed evaluation of student performance in the basic domains, speech, oral expressiveness, and attitude. If a student needs tutoring, schools evaluate student performance with the parents, note the factors impeding progress, and suggest further measures.

Grade-retention policy has been subject to change in recent years. Schools do not usually recommend that students in the lower primary grades repeat a year, although parents may make that request. In 2007, it was argued that parents should have a greater say on this issue, and the Public Education Act was amended so that grade retention in Grades 1–4 required parental consent. However, this amendment was revoked in 2010 based on the argument that grade retention should be a purely professional decision made by teachers.

Impact and Use of TIMSS

Hungary has participated in every cycle of TIMSS since 1995. Before 2001, international assessments of student performance received little attention in the national media.[14] Further, educational decision makers, parent associations, school administrators, and teacher's associations paid little attention to the international reports. However, Hungary's poor performance on PISA 2000 was a catalyst for the national media to begin covering results from international comparative education research as well as from Hungarian national assessments.

Beginning in the 2001–02 academic year, Hungary implemented its National Assessment of Basic Competencies (NABC) to examine student performance in reading and mathematics and to begin addressing perceived weaknesses in the education system. In conjunction with this initiative, support was offered to teachers who wished to become trained in assessment and evaluation. As a result, hundreds of teachers have graduated from two-year university programs as experts in these fields. Today, the public education sector is more open to data- and evidence-based school reform.

International survey results are now routinely disseminated to both the public and education sectors. On December 11, 2008, a press conference was held at the Ministry of Education about the findings from TIMSS 2007, focusing on international and Hungarian results. In tandem with the international release, the Hungarian TIMSS team produced a national report.[a]

TIMSS 2007 data also have been made available to researchers for secondary analyses, and a workshop was organized to train educational researchers and sociologists on using international assessment databases. Researchers in university pedagogy departments also now utilize data from TIMSS 1995 through TIMSS 2003, while educational policy makers still refer to the TIMSS 1995 data as well as others surveys.

Several conferences have been held to discuss the results of Hungarian national assessments, as well as TIMSS, PIRLS, and PISA results, with the goal of more broadly disseminating outcomes to school administrators, directors, and teachers, as well as education experts. For example, a conference organized by the mathematics and science departments of several universities focused on mathematics in public education in relation to TIMSS and PISA. In particular, topics of discussion included assessment results and methodology, trends in student knowledge of science, a comparison of TIMSS and PISA, and better application of conclusions about the development of mathematical thinking at primary and secondary school.

TIMSS results also have been used to make practical changes in teaching and learning. For example, research using TIMSS trend results helped reveal problems in science instruction. TIMSS trend data also have stimulated the creation of teacher associations in the subject areas of biology, chemistry, and physics.

a This report is available in English on the Educational Authority website, accessible at http://timss.hu/KMEO-TIMSS 2007-English.pdf

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Indonesia

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Introduction

Overview of the Education System

National education in Indonesia is based on Pancasila—the philosophical foundation of the Indonesian state set forth in the 1945 Constitution of the Republic of Indonesia and enacted June 2003 with respect to national education in Law Number 20.[1] The goal of national education is to develop the nation's capability, character, and civilization by enhancing its intellectual capacity and developing students' human values: being faithful and pious to one and only one God; possessing a moral and noble character; being healthy, knowledgeable, competent, creative, and independent; and acting as democratic and responsible citizens.

Education in Indonesia is structured in streams consisting of formal education, non-formal education, and informal education. These streams can complement and enrich each other through face-to-face classroom interactions, which may be supplemented or replaced with distance learning at later grades. Formal education consists of three levels—basic, secondary, and higher education—and includes several types—general, vocational, professional, vocational-technical, religious, and special education. All streams, levels, and types of education are educational units organized by the national government, local governments, the community, or any combination thereof.

Early childhood education is provided prior to basic education in all streams (formal, non-formal, and informal education). In the formal education stream, early childhood education is available through general or Islamic kindergartens (*Taman Kanak-Kanak*, or *Bustanul Athfal/Raudatul Athfal*, respectively). In non-formal education, early childhood education place in play groups (*Kelompok Bermain*), child care centers (*Taman Penitipan Anak*), or other similar settings. In informal education, early childhood education takes the form of family education or education in the community.

Basic education is the foundation for secondary education and takes place in two stages: primary, Grades 1–6 (ages 7–12); and junior secondary, Grades 7–9 (ages 13–15). Primary education is provided at general or Islamic primary schools (*Sekolah Dasar* or *Madrasah Ibtidaiyah*, respectively), or other schools of the same level. Junior secondary education is provided at general or Islamic junior secondary schools (*Sekolah Menengah Pertama* or *Madrasah Tsanawiyah*, respectively), or other schools of this level.

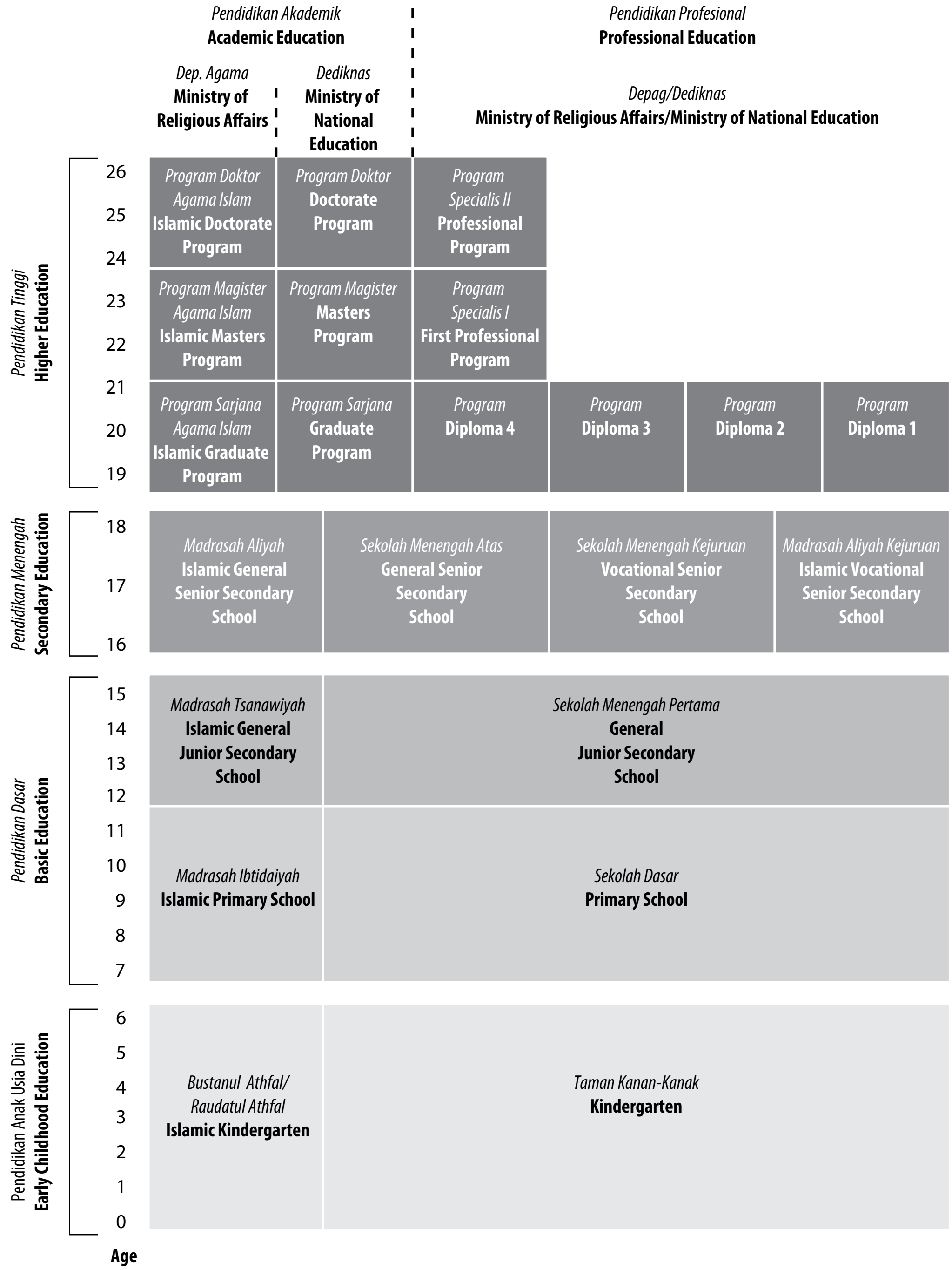
Secondary education (Grades 10–12, ages 16–18) is the continuation of basic education and comprises general secondary and vocational secondary education. This level of education is provided at general and Islamic senior secondary schools (*Sekolah Menengah Atas* or *Madrasah Aliyah*, respectively) in addition to vocational senior secondary schools (*Sekolah Menengah Kejuruan*), and Islamic vocational senior secondary schools (*Madrasah Aliyah Kejuruan*), or other schools of this level.

Higher education follows secondary education and consists of diploma, bachelor's (*sarjana*), master's, doctoral, and specialized postgraduate programs. Higher education is provided by academies, polytechnics, schools of higher learning or specialization (*sekolah tinggi*), institutes, or universities. These institutions provide education, research, and community services and offer academic, professional, and vocational and technical programs. The structure of Indonesia's formal education system is presented in Exhibit 1.

Non-formal education is provided for community members as a replacement, complement, or supplement to formal education to support lifelong learning.[3] Non-formal education aims to develop student potential with an emphasis on acquiring knowledge and functional skills, as well as personal and professional attitudes. This type of education includes the following: life skills; early childhood, youth, and women's empowerment and literacy education; vocational training and internships; equivalency programs; and other kinds of education aimed at developing student abilities.

Families and communities provide informal education in place of formal education. Upon completion of informal education, students have the opportunity to take an assessment measuring their achievement according to the national education standards. If students are successful, their informal education is recognized as equivalent to formal and non-formal education.

Exhibit 1: Formal Education System, According to Law No. 20, 2003[2]



In accordance with the law, religious education is provided by the national government or by any group of people belonging to the same religion. Religious education prepares students to become community members who understand and practice religious values, and it provides a channel for students to acquire expertise in religious studies. Religious education is conducted in formal, non-formal, and informal education streams.

Special education is provided for especially gifted learners as well as for students who have difficulty following the typical learning process because of physical, emotional, mental, or social disabilities. Education with special services is provided for students in remote and less-developed areas, isolated areas, and for students who are victims of natural disasters, suffer from social disabilities, or who are economically disadvantaged.

Distance education is organized in all streams, levels, and types of education and provides services to any group of people in the community who cannot attend face-to-face or regular classes. Distance education is organized in various forms and is supported by learning facilities and services as well as through an assessment system, which ensures that the quality of graduates meets national education standards.

Languages of Instruction

Bahasa Indonesia is the official language and the primary language of instruction in Indonesia. The country has many population subgroups based on either language or ethnicity, the largest of which are Javanese and Sumatran. These regional languages also are commonly used as languages of instruction in combination with Bahasa Indonesia. English is officially taught beginning in Grade 7.

Mathematics Curriculum in Primary and Lower Secondary Grades

Exhibit 2 presents the topics or skills students should have been taught by the end of Grade 8, according to the National Mathematics Curriculum.

Exhibit 2: Mathematics Curriculum Covered by End of Grade 8

Domain	Topic	Skills
Number	Whole Numbers	Understanding place value, factorization, the four arithmetic operations (addition, subtraction, multiplication, and division), computations, estimations, and approximations.
	Fractions and Decimals	Using common fractions, including equivalent fractions, ordering of fractions and decimals, such as by place value, and converting to common fractions and vice versa; Representing decimals and fractions using words, numbers, or models (including number lines); and Computing using the four arithmetic operations with fractions, decimals, and percents.
	Integers	Representing, comparing, ordering, and computing with integers.
	Ratios, Proportions, and Percents	Understanding equivalence, dividing a quantity by a given ratio, and converting percents to fractions or decimals, and vice versa.
Algebra	Patterns	Extending numeric, algebraic, or geometric pattern or sequences using words, symbols, or diagrams; and Finding missing terms and generalizing pattern relationships in a sequence, between adjacent terms in a sequence, or between the number of the term in a sequence and the term itself using words or symbols.
	Algebraic Expressions	Finding sums, products, and powers of expressions containing variables.
	Equations and Formulas	Solving problems using equations or formulas.
Geometry	Lines and Angles	Identifying angles (e.g., 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	Identifying properties of geometric shapes (e.g., triangles, quadrilaterals, and other common polygons), applying geometric properties to solve problems, and calculating lengths of lines, surface areas, or volumes of shapes and solids (e.g., squares and cubes).
	Congruence and Similarity	Identifying congruent and similar features of shapes.
	Symmetry and Transformations	Identifying transformation results from applying translations, rotations, and reflections.
Data Management (Primary School) **Statistics and Probability (Secondary School)**	Data Collection and Organization	Calculating and displaying the mean, median, range, and shape of distributions (in general terms), and determining sample sizes for random experiments.
	Data Representation	Constructing tables, pictographs, bar graphs, pie charts, and line graphs.
	Data Interpretation	Interpreting data sets by drawing conclusions, making predictions, and estimating values between and beyond given data points.
	Uncertainty and Probability	Judging the probability of an event.

Science Curriculum in Primary and Lower Secondary Grades

Exhibit 3 presents the topics or skills students should have been taught by the end of Grade 8 or 9, according to the national content standard of science.

Exhibit 3: Science Curriculum Covered by End of Grade 8 or 9

Science Subject	Taught by	Content
Biology (Based on the 2011 National Content Standards and Including Environmental Science)	End of Grade 8	Characteristics and classification of living organisms; variety in the structure of living organisms; ecosystems; 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; transport systems in plants; and plant diseases.
	End of Grade 9	The human excretory and reproductive systems; the human nervous system and senses; adaptation, selection, and reproduction in living organisms; heredity in living organisms; biotechnology applications in agriculture.
Chemistry	End of Grade 8	Properties of acids, bases, and salts; elements and simple chemical formulas; characteristics of elements, compounds, and mixtures; atoms, ions, and molecules; matter and density; physical and chemical changes; and chemical substances in everyday life.
Physics	End of Grade 9	Measurement; scales and units; motion, force, and energy; vibrations and waves; optics; electricity; magnetism; the solar system; sound and light; and electrical energy.
Earth Science (Part of Social Science)	End of Grade 9	Earth's structure, processes, cycles, history, and physical features (e.g., 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 Materials, Equipment, and Laboratories

All mandatory books must be approved by content specialists and, according to the 2005 Ministry of Education Act Number 11, mathematics and science textbooks must be approved by the National Standard Board for Education. In addition to the approved texts, other instructional materials are used to enrich and further explain the curriculum. Some schools are well resourced with essential equipment and laboratories.

Use of Technology

Computer skills are formally taught beginning in the seventh grade. Some schools are well equipped with computer labs and multi-media centers, so mathematics and science teachers can incorporate this technology into their lessons.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Generally, primary teachers (Grades 1–6) are responsible for instruction in all subjects. However, in some schools, students have specialist teachers in mathematics and science beginning in Grade 4.

Homework Policies

There are no specific policies on assigning homework. Teachers have the authority to decide the frequency, type, and quantity of homework students will do.

Teachers and Teacher Education

Teacher Education Specific to Mathematics and Science

Currently, primary teachers (Grades 1–6) are required to have a two-year diploma (certificate D-2) in order to teach. However, under the updated teacher education requirements passed in 2005, by the year 2015 all teachers will be required to complete a four-year university degree and obtain teacher certification.[4]

Secondary school teachers (Grade 7 and higher) must complete either a university degree in the subject they wish to teach in addition to pedagogical training or a university degree in education. These programs typically last four or five years. During their university study in departments of education, prospective mathematics and science teachers spend about 60 percent of their total time studying mathematics or science, with the other 40 percent devoted to studying pedagogy.

The Ministry of Education provides scholarships and professional training in all subject areas through the Institute for Educational Quality Assurance. In addition to academic and pedagogical studies, prospective teachers must complete a teaching practicum.

Requirements for Ongoing Professional Development

Indonesia does not have enough qualified teachers outside of Java Island, especially in rural areas, and the most effective teachers prefer to work on Java Island. In some cases, teachers teach subjects other than those they have studied. In order to update teacher competencies and encourage professionalism, the Institute for Educational Quality Assurance offers mathematics, physics, and biology teachers a number of professional development activities and training programs, including training in innovative approaches to teaching these subjects using technology and training in classroom assessment techniques.

In 2008, the Indonesian government started the Better Education through Reformed Management and Universal Teacher Upgrading project which supports teacher professional development programs, teacher education programs, and provides incentives to teachers to upgrade their skills.

Monitoring Student Progress in Mathematics and Science

Teachers and schools monitor individual student progress through grades and report cards. In Grades 1–6, there are no examinations for promotion; rather, teacher evaluations in the form of report cards are used to make decisions about grade promotion. At the end of each school year, students are promoted to the next grade based on their grades. Periodically, parents receive school reports of their child's progress, which must 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.

Indonesia monitors student progress in mathematics and science through national and regional examinations and surveys, and students take national and regional examinations throughout their formal schooling. Beginning in junior secondary school (Grades 7–9), students take national examinations, which are used together with report cards to determine promotion (with the following weight: 60% examination scores, and 40% report cards). Special exams are taken at the end of Grades 6, 9, and 12 for entry into the next level of education (i.e., junior secondary, senior secondary, and university education). Every semester in Grades 7 through 12, students take a regional examination that is either formative or summative; the formative examinations monitor learning, and summative examinations determine promotion to the next grade. In addition, a national high-stakes examination at the end of Grades 9 and 12 tests mathematics, Bahasa Indonesian, and English and students obtain certificates for passing these examinations. The pass-fail decision is based on a combination of the results from the national examination and from relevant subject matter examinations conducted by the districts. The national examination is required for students who wish to continue their studies in a university or other higher education program.

National surveys, such as TIMSS, are administered to obtain more comprehensive insight into student performance. National and regional examinations only use multiple-choice format items, but the national surveys also employ constructed-response format items, allowing students to formulate responses for themselves.

Impact and Use of TIMSS

Indonesia's participation in TIMSS has resulted in the Ministry of Education giving increased attention to revising the mathematics and science curricula. Further, in the reformed educational system (in place since 2006), chemistry has been added to the national content standards for science.

Suggested Readings

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Islamic Republic of Iran

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Introduction

Overview of the Education System

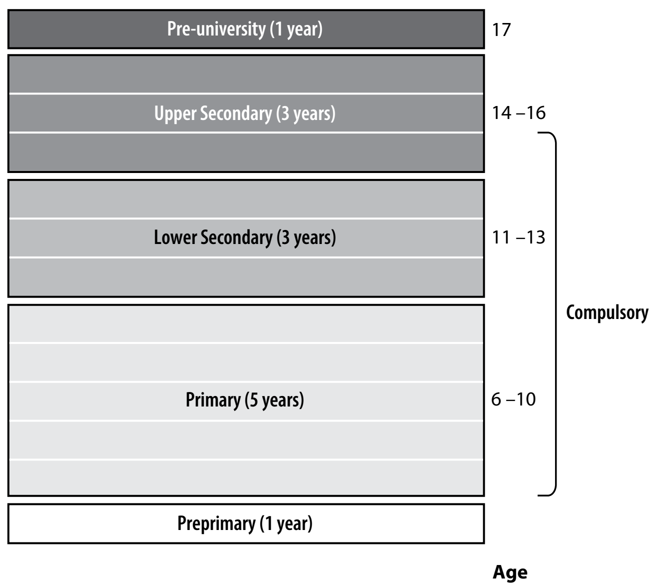
Islamic principles and precepts form the basis of the Islamic Republic of Iran's constitution, which attributes great importance to education.[1] According to Article 3 of the constitution, the government is responsible for providing free education and strengthening the spirit of inquiry and investigation in all areas of science, technology, culture, and Islamic studies through secondary school.[2] Religious minority groups, including Christians, Jews, and Zoroastrians, are free to teach, perform their religious rites, and act according to their own canons in matters of personal affairs and religious education.

The structure of Iran's education through the upper secondary level is highly centralized. The Ministry of Education administers and finances schools at the primary and secondary levels (Grades 1–12) and is responsible for teacher education, grading, and examinations. The Ministry of Education is composed of several deputy ministries with specific educational administrative responsibilities, including developing and planning goals, conducting and supervising educational activities, developing curricula and textbooks, publishing and distributing educational materials, planning and conducting professional development for teachers, and defining human resource policies within the ministry. The Supreme Educational Council, an autonomous legislative body, approves all policies and regulations related to formal pre-tertiary education, and sets the educational goals for Grades 1–12 according to Islamic principles.

At the tertiary level, the Ministry of Science, Research, and Technology is responsible for universities offering nonmedical degrees; the Ministry of Health and Medical Education is responsible for medical schools and paramedical degrees; and the Ministry of Labor and Social Affairs is responsible for non-formal vocational education.

The formal education system in Iran includes one year of preprimary education, which children begin when they are age five, followed by five years of primary education. At age eleven, children begin three years of lower-secondary education, followed by three years of upper-secondary education and one year of pre-university education (see Exhibit 1). Education is only compulsory through the first year of upper-secondary school, after which students are able to choose the track of their studies.

Exhibit 1: Education System in the Islamic Republic of Iran



Iran has both public and private schools at all levels, from elementary school through university. Approximately 9 percent of upper-secondary institutions are private.[3] These schools must conform to the regulations of the Ministry of Education, though they are financed primarily through tuition fees received from students. Public schools in Iran are free to all citizens.

The preprimary year prepares children for the formal primary stage of education. A course in Farsi is required in bilingual areas of the country where Farsi is not the mother tongue. In these communities, Farsi is taught in addition to regular preprimary activities. The Organization for Educational Research and Planning is responsible for the supervision and educational preparation of preschool centers. Preschools may be public or private and may cater to only boys or girls, although many admit both. With no examination at the end of this stage, children are automatically promoted to the next stage.

The main objectives of preprimary education are the following:

- 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; and
- Prepare children for social relationships and cooperation.

Primary education, the first stage of formal education, lasts five years (Grades 1–5) for students ages 6–10. The main objectives of this stage are to:

- Create an atmosphere for moral and religious development;
- Develop literacy and numeracy skills;
- Develop social skills;
- Instruct students about personal hygiene; and
- Develop students' talents, abilities, and physical strength.

The subjects taught in primary school include Holy Quran, Farsi (reading, writing, and dictation), mathematics, science, religious education, social studies (e.g., history, geography), art, and physical education. One teacher typically is responsible for teaching all subjects except religion, art, and physical education.

The lower-secondary stage of education lasts three years (Grades 6–8) for students ages 11–13. At this stage, students become familiar with various subjects in the physical and social sciences, as well as humanities and art. The main goals of the lower-secondary stage are the following:

- Develop moral and intellectual abilities;
- Increase general knowledge;
- Strengthen academic discipline and scientific imagination; and
- Identify individual preferences and talents in order to direct students toward suitable programs of study.

In addition to the subjects taught at the primary level, students in lower secondary receive second-language instruction of their choosing (English, French, or German), vocational education, and defense education (for boys only).

Upper-secondary education is three years (Grades 9–11) for students ages 14–16. The first year of this stage is the same for all programs of study. In the second year, students choose among academic (theoretical), technical and vocational, and *Kar-Danesh* (Skill-Knowledge) tracks of study. These programs have different objectives and are intended for students with different abilities and interests. Academic programs prepare students to enter university, and students who select these programs focus on mathematics, natural science, or social science, based on their education and career interests. Technical and vocational and *Kar-Danesh* programs both prepare students for participation in the labor market after finishing high school and lead to either a Post-Diploma degree or a Skill Certificate, respectively. Students who complete either of these programs have the opportunity to continue their education through vocational colleges, where students choose a program based on their capabilities and interest. Alternately, graduates of these programs may also take the Pre-university examination. Three components comprise the curriculum of each program: common subjects, which are common courses for all programs of study regardless of the track (i.e., Holy Quran, religious education, Farsi literature, statistics, Arabic, foreign language, and physical education); elective subjects (e.g., art of problem solving, mathematics, physics); and specialized subjects that are program-specific.[4] At the end of the upper-secondary stage, a final examination is administered nationwide.

Pre-university is a one-year program (Grade 12) for upper-secondary graduates that would like to participate in university entrance examinations in order to further their education.[5]

Languages of Instruction

Article 15 of the Iranian constitution states that the "Official language (of Iran)... is Persian...[and]...the use of regional and tribal languages in the press and mass media, as well as for teaching of their literature in schools, is allowed in addition to Persian."[6] The population of Iran is approximately 75.8 million[7] with a literacy rate of 83 percent, with Persian being the mother tongue of at least 65 percent of the population and spoken by a large proportion of the remaining 35 percent.[8] Iran is a diverse country consisting of people with many ethnic backgrounds: Persians (65%); Azerbaijanis (16%); Kurds (7%); Lurs (6%); Arabs (2%); Baluchis (2%); Turkmens (1%); Turkic tribal groups, such as the Qashqai (1%); and non-Iranian, non-Turkic groups, such as Armenians, Assyrians, and Georgians (less than 1%).[9] Languages other than Persian spoken in Iran include Turkish, Azeri, Kurdish, Luri, and Mazandarani.

Mathematics Curriculum in Primary and Lower Secondary Grades

The Ministry of Education is responsible for conveying the standards and principles of mathematics. The ministry's guidelines for mathematics emphasize the following areas: mathematics content (basic and essential facts and concepts), mathematical processes (problem solving, modeling simple real-life situations, making hypotheses and evaluating them, estimating, and reasoning), and general skills (critical and creative thinking, observation, abstraction and generalization, comparing and ordering, and classifying and sorting).[10] The recommended approach to teaching and learning involves students problem solving and participating in class or group activities.

By the end of fourth grade, students should have learned the following topics:

- Number and Operations—Whole numbers and their representations; estimation and computation with whole numbers; place value; the meaning of fractions and equivalent fractions; comparing and ordering of fractions; operations with fractions, such as adding and subtracting; number patterns and extension of patterns; and modeling simple situations.
- Geometry and Measurement—Metric units; measuring angles; length; areas of common two-dimensional shapes; parallel lines; comparison of angles; properties of common geometric shapes; calculation of the perimeter and area of parallelograms, rectangles, triangles, and squares; and figures with lines of symmetry.
- Data Handling—Pictographs and simple block diagrams.

By the end of eighth grade, students should have learned the following topics:

- Number and Operations—Multiplication and division of fractions and decimals and operations on them; conversion of fractions to decimals and vice versa; integers and computation with integers; ratio, proportion, and percent; mixed numbers, addition and subtraction of mixed numbers, and multiplication of mixed numbers by a whole number; and exponents and square roots.
- Geometry and Measurement—Types of and relationships between angles; angles formed by a transversal that intersects parallel lines; perpendicular lines; congruent triangles and conditions for congruency; constructing congruent triangles; similar triangles and their properties; the Pythagorean Theorem; three-dimensional objects and their relationships to two-dimensional shapes; the surface area and volume of a cylinder; rectangular prisms, cubes, spheres, and pyramids; circles, tangents, and angles; circumference and area of a circle; irregular

compound areas; Cartesian planes, intersections, and slopes; reflection and rotational symmetry; and translations.

- Algebra—Expressions; sums, products, and powers of algebraic expressions; simplifying algebraic expressions and evaluating algebraic expressions for given values; linear equations, slope, and systems of simultaneous equations in two variables; and ordered pairs and coordinate systems.
- Probability and Data—Chance, bar graphs, line graphs, histograms, and means.

Science Curriculum in Primary and Lower Secondary Grades

The current National Science Curriculum was introduced in 1994 at the primary level and in 2000 at the lower-secondary school level. Science education focuses on fostering logical thinking skills and preparing for lifelong learning. The curriculum focuses on the following: learning basic science facts; observing and acquiring skills; acquiring a positive attitude toward physical science, life science, health, and earth science; and understanding important applications of science in real life. The science curriculum teaches students to be able to make observations and measurements, collect data, analyze results, make hypotheses, communicate, predict, use instruments, and plan and conduct an investigation. Students should think about and search for the causes of phenomena and develop a sense of curiosity about natural phenomena in their environment. They should use their skills to investigate answers to their questions about science, learn to save energy and time, observe personal and public hygiene, and become interested in environmental issues. The recommended approach to teaching and learning involves students in problem solving, actively participating in practical activities, and conducting experiments.

By the end of fourth grade, students should have learned the following topics: [11]

- Life Science—(Animals) diversity; habitats and the need for keeping the environment clean; types of food; types of locomotion; nesting and migration; comparisons of different animal coverings (skin, fur, feathers, scales, etc.) and the advantage of different coverings in relation to animal needs; classification of vertebrates and invertebrates; types of parasites; and the body structure and characteristics of living things; (Plants) parts of plants and their structures and the function of roots, stems, leaves, flowers, fruits, and cones; plants used to make clothing; growth of plants and different factors affecting seed growth; comparisons of monocotyledons and dicotyledons; classification of plants; the structure and function of cells; photosynthesis; the role of vessels in plants; and plant uses in nutrition, agriculture, and pest control.

- Earth Science—Sources, purification, and uses of water; rocks, minerals, sand, and soil; use and conservation of Earth's natural resources; the solar system; Earth's rotation on its axis causing day, night, and shadows; and air and its purification.
- Health—Senses and learning through the senses; protection of eyes and ears; staying healthy; factors affecting growth; the digestive system and its function; bones and muscles; the respiratory system; and blood circulation.
- Physical Science—(Matter) states of matter; volume, mass, and density; the structure of matter; types of mixtures, and solutions and solvents; (Heat) temperature changes; the effect of color on absorbing sunlight; applications of heat, and heating appliances; sources of heat; what materials to wear in cold and warm environments; state changes and the effect of heat on states of matter; and how to construct and use a thermometer; (Motion) moving and stationary objects; wheels and their applications; how motion is affected by surface type and weight of an object; (Force) force and the effect of force on the movement of objects; and the Earth's gravity; (Energy) types, use, and conversion of energy and sources of energy; (Light and Reflection) the role of light in vision; sources and applications of light; refraction; shadows; types of mirrors, and images formed by mirrors and their applications; (Electricity) electric currents; series and parallel circuits; and insulators and conductors; (Magnets) shapes, interactions, and applications of magnets; electromagnets; magnet poles; and navigation by compass.

By the end of eighth grade, students should have learned the following topics: [12]

- Life Science—Classification of living things; organ systems in humans; cell structure and function; photosynthesis and respiration; life cycles of organisms; interactions of living organisms in ecosystems; the cycle of materials in nature; trends in human population and effects on the environment; the impact of natural hazards on humans, wildlife, and the environment; microorganisms and infectious diseases; transmission and prevention of disease; and preventive medicine.

- Earth Science—The atmosphere and its components; the water cycle (steps, the sun's role, and fresh water renewal); processes in the rock cycle and the formation of igneous, metamorphic, and sedimentary rocks; the Earth's resources (renewable and non-renewable, conservation, and waste management); and supply and demand of fresh water resources.
- Physical Science—(Physics) temperature and the measurement of heat; the effect of heat on the processes of melting, freezing, evaporation, and condensation (including phase change, melting and boiling points, and volume); pressure; energy forms; basic properties and behavior of light (reflection, refraction, color, image formation in mirrors, and lenses); waves; conservation and transformation of energy; simple machines; power; work; sound; electric currents and circuits; conductors and insulators; resistance; properties of permanent magnets and electromagnets; forces and motion; mass and weight; distance and displacement; and velocity and acceleration; (Chemistry) classification of matter (physical and chemical properties, pure substances and mixtures, and separation techniques); the particulate structure of matter (molecules, atoms, protons, neutrons, movement of particles, electrons, the atomic model, symbols and notations, atomic bonds, molecular bonds, and ions); solutions (solvents, solutes, and solubility); acids and bases; chemical changes and reactions; conservation of mass; endothermic and exothermic reactions; and physical changes.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

For all grade levels, the school year is approximately nine months long. It begins on September 21 of each year and ends on June 21 of the subsequent year. Schools operate Saturday through Thursday.

Total instructional time at the primary level is 24 periods per week of 40–45 minutes each. For fourth grade mathematics, instruction time is three hours and 20 minutes per week, which is 16 percent of total instructional time. For fourth grade science, instruction time is two hours and 15 minutes per week (three periods of 45 minutes each), which is 13 percent of the total instructional time per week. The total instructional time in lower secondary (Grades 6, 7, and 8) are 28, 29, and 30 periods per week, respectively. Total instructional time for eighth grade mathematics and science is thr hours and 20 minutes per week each (4 periods, each 50 minutes), which is 11 percent of total instructional time.

Instructional Materials, Equipment, and Laboratories

The Organization for Educational Research and Planning prepares all textbooks and curriculum materials. Mathematics and science textbooks up to the eighth grade level are accompanied by a teacher's edition and teacher's guide, which include recommendations for teaching and learning, assessment methods, and student activities. Almost all teachers use additional workbooks of their own choosing to supplement these materials. In primary schools, the use of assessment instruments to measure student achievement is suggested.

In science, the program of study includes the use of laboratories, which also may be used for extracurricular activities. Both the Ministry of Education and individual schools fund the equipment for laboratories.

Use of Technology

Use of video tapes, overhead projectors, calculators, and computers in all subject areas and for all grade levels is recommended but not mandated. Individual schools and teachers make decisions about whether to use such equipment, subject to availability. Currently, several schools in large cities use educational software or integrate use of the Internet into their curriculum. The Ministry of Education prepares some instructional tapes and CDs for schools to use.

Grade at Which Specialist Teachers for Mathematics and Science are introduced

In almost all middle schools and, recently, in some primary schools (at the fourth and fifth grades), mathematics and science are taught by specialist teachers.

Homework Policies

There is no homework policy for mathematics and science. Teachers assign homework as needed according to their schedules, usually at the end of every instructional session.

Teachers and Teacher Education

Prior to 2002, the majority of teachers and educational staff in Iran received qualifications from the Ministry of Education's Higher In-Service Education Center. Since 2002, universities and higher education institutes have offered in-service, long-term degree programs.

Mathematics and science teachers complete one of two long-term teacher education courses or programs. These courses are offered at the associate, bachelor's, and master's degree levels: [13]

1. Teacher education centers affiliated with the Ministry of Education's Bureau of Scientific Promotion of Human Resources—These post-secondary institutions offer two-year programs leading to an associate degree. Programs are available to high school graduates who have passed the national higher education entrance examination. Enrolled students receive housing for the duration of their program. Programs offered include mathematics, science, physical education, social studies, primary education, Persian language and literature, internal affairs (i.e., graduates of this program provide pedagogical advice, plan leisure time and school activities, and work in student affairs), Islamic and Arabic language, art, and special education (i.e., graduates of this program learn to teach students with mental or physical disabilities). Graduates from these courses can teach in primary or lower-secondary schools.

2. Teacher education programs at universities and higher education institutions—These institutions offer four-year preparation programs leading to a bachelor's degree. Eligible candidates are high school graduates who have passed the national higher education entrance examination. Once admitted, students are required to take courses in pedagogy and educational psychology, along with specialized courses in their subject area. Graduates from these programs teach all subjects at the primary or secondary levels, including mathematics and science, except physical education, art, and the Quran.

Requirements for Ongoing Professional Development

To improve teacher knowledge and skills, the Ministry of Education's Bureau for the Scientific Promotion of Human Resources has developed short-term courses and workshops providing both general and specific education content. These courses are offered in different institutes for all ministry staff, including teachers. The goal of short-term training courses is to improve specific teacher and educational staff competencies. Some of these courses are compulsory, such as those for pre-employment training, training for promotion, and teacher education about newly implemented policies.[14] Teachers also are required to take computer literacy courses to advance proficiency in technology.

Expert teachers, responsible for monitoring and mentoring teachers in different subjects, are available in all districts. Provincial offices of the Ministry of Education have professional, instructional, and educational associations to provide resources to teachers. The Curriculum Development Center and other offices also provide assistance and instruction to mathematics and science departments and teachers.

Monitoring Student Progress

Educational evaluation up to fourth grade involves continuous formative assessment, including observation of students' in-class activities, in-class oral or written exams, and homework. Schools issue descriptive report cards for each individual student in October and June. Students who do not attain the satisfactory level for promotion to the next grade must participate in compensatory sessions and complete further enrichment activities by September.[15]

After Grade 4, educational evaluation includes both formative and summative assessments. Teachers develop examinations that are administered twice each year to determine grade promotion. At the end of Grade 5, students take a regional examination developed by the Office for Assessment in the Ministry of Education in each province. Those who pass the examinations receive elementary school-leaving certificates, while those who fail have the opportunity to retake the examination in September. Students who fail a second time have the opportunity to retake the examination the following year. The grading system at this stage uses points earned through continuous assessment and criterion-referenced written and oral examinations. Ten points (out of 20) are required for promotion.

The system of promotion in lower-secondary school is similar to that used in the primary stage. At the end of the lower-secondary stage, students in each province take a regional examination, and those who pass receive certificates of general education. At the end of upper-secondary education, a national final examination leads to a high school diploma.[16]

Impact and Use of TIMSS

Since the 1995 assessment, TIMSS results have informed modifications to the Iranian education system. Objectives for mathematics and science teaching were evaluated following both the publication of TIMSS outcomes and analyses of factors contributing to Iranian achievement results. Based on updated objectives, revisions to specific curriculum components have been considered.

For example, an analysis of fourth- and eighth-grade student performance in mathematics found weaknesses in certain content areas. At the primary stage, students had difficulties working with fractions and thinking visually, while at the lower-secondary stage, students had difficulties with algebraic thinking and statistics (e.g., interpreting diagrams and graphs). This information was communicated to curriculum planners and textbook editors. In addition, a comparative analysis of textbooks was conducted as a result of Iranian students' performance on TIMSS. The textbooks of high-performing TIMSS countries were consulted to inform the revision of Iranian texts.

The eighth-grade science framework also was reviewed following TIMSS 1999. The Earth Science curriculum was updated to align more closely with the TIMSS framework, leading to better performance in that content area in later assessments.

At the school level, TIMSS released items for Grades 4, 8, and 12 have been disseminated to teachers to incorporate into their teaching. Cognitive classifications used in the TIMSS assessment also were introduced to teachers through teacher editions of textbooks. Professional development sessions have been conducted in order to introduce the TIMSS frameworks and their goals and objectives to teachers.

Finally, research opportunities and potential research topics using TIMSS results have been introduced to masters and doctoral students majoring in mathematics education and curriculum planning.

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Ireland

Department of Education and Skills
National Council for Curriculum and Assessment

Eemer Eivers
Educational Research Centre

Introduction

Overview of the Education System

Ireland's education system is largely centralized. Overall responsibility for education lies with the Minister for Education and Skills, who is a member of the Irish government and responsible to the national parliament. In practice, the Department of Education and Skills (DES), together with a number of bodies under its aegis, is responsible for running the Irish education system. Almost all primary and post-primary schools are state-funded, and are required to operate under both the Education Act (1998)[1] and the curriculum, assessment, and evaluation framework established by the DES, based on advice from the National Council for Curriculum and Assessment (NCCA). The NCCA is a statutory body with responsibility for advising the Education Minister on curriculum and assessment for early childhood education and for primary and post-primary schools. The inspectorate division of the DES has responsibility for evaluating and reporting on educational provision in all primary and post-primary schools and centers of education that are supported by the Department. Although state-funded, the majority of schools are owned and managed by private organizations, mainly church authorities or religious orders. Individual boards of management govern each school, which are expected to operate in accordance with centrally agreed-upon procedures.

The Irish education system comprises primary, post-primary, third-level, and further education. In addition, parents can send their children to one year of early childhood care and education, prior to starting primary school. Primary schools operate an eight-year program, consisting of two pre-primary years (Junior Infants and Senior Infants), followed by Grades (Classes) 1–6. A child must be four years old at the start of the school year (September) to enroll in primary school. Most children start school as Junior Infants, at either four or five years of age.

The Irish primary education sector comprises state-funded primary schools, special schools, and private primary schools. The 3,165 state-funded primary schools include religious schools, non-denominational schools, multi-denominational schools, and *scoileanna lán-Ghaeilge* (Irish-medium schools). All state-funded schools follow the Primary School Curriculum[2] and private schools offer a broadly similar curriculum.

Ireland has some variation in post-primary school types (e.g., vocational schools, comprehensive schools, and privately-owned and managed secondary schools). However, the curriculum offered in all is substantially the same. Second-level education consists of a three-year junior cycle followed by a two-year senior cycle. Senior cycle can extend to three years if students opt to complete a "Transition Year" (a year free from formal examinations that allows students to experience a range of educational inputs, including work experience) following completion of junior cycle. Senior cycle students follow one of three programs, each leading to a terminal state examination: the Leaving Certificate, the Leaving Certificate Vocational Programme, or the Leaving Certificate Applied.

At both lower and upper secondary school, students choose one of three levels for mathematics (higher, ordinary, or foundation). At lower secondary, science students are tracked into either higher or ordinary levels of combined science classes, while, at upper secondary, students enroll in individual science subjects, certified at either higher or ordinary level. Differences between levels are mainly in terms of depth, and all sciences have practical elements built into their syllabuses.

In 2011, the DES launched "Literacy and Numeracy for Learning and Life," a comprehensive national strategy to improve literacy and numeracy standards.[3] The strategy complements initiatives such as Maths Week Ireland (an annual, all-island celebration of mathematics) and Discover Science & Engineering (a national science promotion program aiming to increase interest in science, technology, engineering, and mathematics among students, teachers, and members of the public). Further, the annual Young Scientist and Technology Exhibition, funded by private sponsors and supported by the DES, plays a major role in promoting scientific education. For example, the 2010 Exhibition attracted over 1,700 student entrants, and over 40,000—mainly student—attendees.

At the secondary level, both mathematics and science have recently received additional funding. The "Project Maths" initiative is implementing a new mathematics curriculum, with associated professional development, at both lower and upper secondary levels. Generally, the DES funds mathematics and science education, with additional per capita grants for students who study in the physics and chemistry programs leading to the Leaving Certificate.

Languages of Instruction

Ireland is officially a bilingual state; Irish is the national and first official language, and English is recognized as a second official language.[4] In practice, almost all people speak English on a daily basis, while the most recent census data available (2006) indicate that approximately 41 percent of the population are able to speak Irish.[5] Irish is the community language in pockets of *Gaeltacht* (Irish-speaking) areas and is used daily by some people outside the *Gaeltacht*. The Government aims to ensure that as many citizens as possible are bilingual (Irish and English) and is committed to providing the option of Irish-medium education, both in *Gaeltacht* and non-*Gaeltacht* areas. Thus, in addition to English-medium schools, Ireland has Irish-medium primary and post-primary schools in *Gaeltacht* areas, and a network of Irish-medium schools in non-*Gaeltacht* areas (*scoileanna lán-Ghaeilge*). Because fluency in Irish is not a requirement for enrolment at Irish-medium schools, Irish is often not the mother tongue of students attending these schools. In English-medium schools, English is the medium of instruction for mathematics and science at all grades. In Irish-medium schools, Irish is usually the medium of instruction for mathematics. Until relatively recently, a perceived limited range of science texts available in Irish meant that primary-level science was sometimes taught in English. Currently, science in Irish-medium schools is typically taught in Irish, at both fourth and eighth grades.

Mathematics Curriculum in Primary and Lower Secondary Grades

The mathematics component of the Primary School Curriculum is for all students from junior infants (pre-primary) to sixth grade.[6, 7] The mathematics curriculum aims to help all students to achieve the following:

- Develop a positive attitude towards the subject and to appreciate its practical application in life;
- Develop problem-solving skills and the ability to use mathematics in everyday life;
- Use mathematical language effectively and accurately;

- Understand mathematical concepts and processes at a level commensurate with their development and ability; and
- Become proficient in fundamental mathematical skills and in recalling basic number facts.

At fourth grade, the curriculum is presented in five strands: Number, Algebra, Shape and Space, Measures, and Data. The strands are interrelated, so student understanding in one area is dependent on, and supportive of, ideas and concepts in other strands. The strands are divided into strand units, in which student learning is described using content objectives.

Unlike the rest of the Primary School Curriculum, in which learning content for subjects is grouped in two-year grade bands, mathematics learning content is grade-specific. Exhibit 1 shows the curriculum strands and strand units for fourth grade, and provides some specific examples of the types of skills developed.

Exhibit 1: Summary of the Mathematics Curriculum, Grade 4, with Sample Skills

Strand	Strand Unit	Mathematical Learning
Number	Place Value	Round whole numbers to nearest 1,000.
	Operations	Solve word problems involving adding and subtracting numbers 0–9,999.
	Fractions	Solve problems involving fractions.
	Decimals	Order decimals on the number line.
Algebra	Number Patterns and Sequences	Explore, recognize, and record patterns in numbers, 0–9,999; describe sequences.
	Number Sentences	Translate a one-step word problem into a number sentence, and solve.
Shape and Space	Two-dimensional Shapes	Identify, classify, compare, draw, tessellate, and make patterns with two-dimensional shapes.
	Three-dimensional Shapes	Identify, classify, and construct three-dimensional shapes; and Describe relationship of three-dimensional shapes with constituent two-dimensional shapes.
	Symmetry	Use understanding of line symmetry to complete missing half of a shape, picture, or pattern.
	Lines and Angles	Describe intersecting lines and their angles. Classify angles as greater than, less than, or equal to a right angle.

Strand	Strand Unit	Mathematical Learning
Measures	Length	Units of length (m, cm, km): addition, subtraction, multiplication, and simple division.
	Area	Estimate, compare, and measure the area of regular and irregular shapes (cm^2, m^2).
	Weight	Units of weight (kg, g): addition, subtraction, multiplication, and simple division.
	Capacity	Units of capacity (l, ml): addition, subtraction, multiplication, and simple division.
	Time	Times and dates, and the addition and subtraction of hours and minutes.
	Money	Money (euro and cent): addition, subtraction, multiplication, and simple division.
Data	Representing and Interpreting Data	Use data sets.
	Chance	Identify and record outcomes of simple random processes.

Spanning the content outlined in Exhibit 1 are the skills that students should acquire through their mathematical work. These include applying and problem-solving, understanding and recalling, communicating and expressing, integrating and connecting, reasoning, and implementing.

Based on a constructivist approach to learning, the primary school mathematics curriculum places importance on practical experience, whereby students manipulate and use objects and equipment as they develop mathematical concepts and extend their thinking. The curriculum also highlights the significant role of discussion among students, and between teacher and students during mathematical activities. This is considered especially important in helping students make the transition to mathematical symbols and expressions. The curriculum also highlights the importance of helping students develop an understanding of the structure of numbers, and acknowledges the critical role that calculators can play in this aspect of their learning from fourth grade onwards, by which time students are expected to have acquired a mastery of basic number facts and a facility in their use.

The curriculum puts considerable emphasis on mental calculations and the importance of supporting students' use of these in estimating and problem solving. In this way, students are helped to see mathematics as practical, relevant, and important. Given the pervasive nature of mathematics in everyday life, the curriculum also highlights the importance of integration, whereby students have opportunities to use their mathematical understanding and skills in other subjects.

The mathematics curriculum, as experienced in Irish lower secondary level classrooms, is currently being revised. A curriculum and assessment initiative, Project Maths, was introduced to address concerns about the low levels of mathematical ability evident in national and international tests. The initiative includes syllabus changes on a phased basis, accompanied by changes in examinations. The new syllabus strands were introduced in a pilot set of schools in September 2008, and are gradually being implemented in all schools. However, the curriculum in place for the vast majority of lower secondary students in 2010 was that which was introduced in 2000, and it is described next.

The general aims of the 2000 syllabus are to contribute to the personal development of the students and to help provide them with the mathematical knowledge, skills, and understanding needed for continuing their education, and eventually for life and work.

Upon completion of lower secondary school, students should be able to do the following:

- Recall basic facts;
- Demonstrate instrumental understanding;
- Acquire relational understanding;
- Apply their knowledge and skills;
- Analyze information, including information presented in cross-curricular and unfamiliar contexts;
- Create mathematics for themselves;
- Demonstrate the psychomotor skills necessary for the tasks described above;
- Communicate mathematics, both verbally and in written form; and
- Appreciate mathematics and be aware of its history.

Apart from general syllabus aims and objectives, the lower secondary mathematics curriculum also contains level-specific aims and assessment objectives. The main syllabus topics at each level are: sets, number systems (natural numbers, integers, and rational numbers), applied arithmetic and measure, algebra, statistics, geometry (synthetic, transformation, coordinate), trigonometry, and functions and graphs.

Each topic is presented in detail as a list of syllabus "content." Knowledge of mathematics from the Primary School Curriculum (1999) is assumed.

Mathematics is formally assessed as part of the terminal examinations for lower secondary (Junior Certificate), prepared by the State Examinations Commission. Candidates at ordinary and higher levels take two examinations, while candidates at foundation level take one examination. Coinciding with the introduction of the syllabus in 2000, calculator use in all subjects was permitted in the Junior Certificate Examination and their appropriate use in teaching and learning was assumed.

In contrast, the mathematics syllabus being introduced under Project Maths is presented in five strands: statistics and probability, geometry and trigonometry, number, algebra, and functions. Greater emphasis will be given to student understanding of mathematical concepts and the development of knowledge and skills, as well as their application in a problem-solving approach to familiar and unfamiliar situations and to real-life contexts. The syllabus based on Project Maths will be presented at two levels (or tracks): ordinary and higher.[a] The initiative aims to increase the student cohort taking higher level mathematics by 10 percent.

To promote continuity with mathematics learned in primary school, the National Council for Curriculum and Assessment (NCCA) developed a bridging framework,[8] including a common introductory course specified for the start of Junior Cycle (lower secondary) education.

Science Curriculum in Primary and Lower Secondary Grades

Science, together with history and geography, is part of Social, Environmental, and Scientific Education in the Primary School Curriculum in Ireland. The current curriculum was officially introduced to schools in 2003–04, following appropriate professional development for teachers the previous school year. The science curriculum aims to help develop basic scientific ideas and understanding about the biological and physical aspects of the world, as well as the processes through which they develop this knowledge and understanding. The curriculum also aims to foster positive attitudes toward science, and to encourage examination and appreciation of how science and technology affect their lives and the environment.

The science curriculum is presented in four levels, each of which covers two years of primary school. Level 3, for third and fourth grades, is the relevant level for fourth grade TIMSS participants. Planning at individual school and

a Although junior cycle mathematics will be taught at two levels or tracks, it will be examined at three levels: foundation, ordinary and higher. The foundation level examination will be based on the ordinary level syllabus learning outcomes, but set at an appropriate standard.

classroom levels will indicate what is learned in third and fourth grades, when, and how. The curriculum has a skills section and a content section.

The curriculum aspires to provide students with two key types of skills: working scientifically, and designing and making. A constructivist and collaborative approach is central. The curriculum emphasises the importance of starting with students' own ideas and creating new knowledge and learning about scientific concepts through interactions with objects and materials, and with their classmates. By working scientifically, students learn how to do the following:

- Observe and construct hypotheses;
- Predict;
- Plan and carry out investigations emphasizing fair testing;
- Record and analyze results;
- Share and discuss findings; and
- Extend their thinking to accommodate new findings.

Designing and making involves finding practical solutions to problems by exploring and assessing everyday objects in terms of their functionality, their component materials, their design, and using this information to plan, design, make, and evaluate their own artifacts or models. These activities are intended to harness and nurture students' creative and imaginative capacities.

Curriculum content is composed of four strands: living things, materials, energy and forces, and environmental awareness and care. The strands, which are sub-divided into strand units, outline the concepts and ideas to be explored by students as they work scientifically and are involved in designing and making. Students are expected to experience all Level 3 strand units over the course of third and fourth grades. Exhibit 2 shows the strands and strand units for Level 3, and provides some examples of what students are expected to learn within each strand unit.

Exhibit 2: Summary of the Science Curriculum for Level 3 (Grades 3–4), with Sample Skills

Strand	Strand Unit	Scientific Learning
Living Things	Human Life	Be aware of names and structures of some internal and external body organs, and importance of food for energy and growth; and Understand physical changes in males and females to adulthood.
	Plant and Animal Life	Investigate plants and animals in local environments; be aware of those in wider environments; and Discuss simple food chains.
Energy and Forces	Light	Understand that light is a form of energy, comes from natural and artificial sources, and can be broken into different colors; and Be aware of dangers of looking at the sun.
	Sound	Understand that sound is a form of energy, how it is made, and that it travels through materials; and Identify a variety of sounds in the environment.
	Heat	Understand that the sun is the Earth's most important heat source, and that heat can be transferred; and Know what temperature is, and use a thermometer.
	Magnetism and Electricity	Classify materials as magnetic and non-magnetic, and as conductors and insulators; and Be aware of dangers of electricity.
	Forces	Explore how objects move; are slowed down; and Explore how levers can help lift objects
Materials	Properties and Characteristics	Recognize materials can be solid, liquid, or gaseous; Distinguish between raw and manufactured; Compare and group materials; and Investigate use of materials in construction.
	Materials and Change	Explore effects of heating and cooling on solids, liquids, and gases; and Explore ways to separate materials.
Environmental Awareness and Care	Environmental Awareness	Identify positive aspects of natural and built environments; be aware of interrelationships between living and non-living elements; and Recognize how people's actions affect environments.
	Science and the Environment	Explore application and positive contribution of science and technology to society; and Investigate positive and negative effects of human activities on environments.
	Caring for the Environment	Look at ways for improving local environment; and Nurture a sense of responsibility towards the Earth.

A revised syllabus for Junior Certificate (lower secondary level) science was introduced in September 2003. The course is a practical, investigative one emphasizing hands-on student involvement in learning. Students are expected to develop not only knowledge and understanding of content areas, but also core scientific skills, and an awareness and appreciation of science. Teachers are encouraged to use a variety of teaching methodologies that enable students to work scientifically and apply their scientific knowledge.

The lower secondary science curriculum contains three main syllabus sections, each of which is further divided into three more detailed topic areas, as shown in Exhibit 3. Although not compulsory, approximately 90 percent of lower secondary students take science as a subject. The curriculum provides a suitable preparation, but is not a requirement, for the study of one or more science subjects at the upper secondary level. Topics are accompanied by learning outcomes that reflect an investigative and practical approach. All students must study the three syllabus sections at either the higher or ordinary level.

Exhibit 3: Main Topic Areas for Lower Secondary Level Science Syllabus

Science Subject	Topic Area
Biology	Human Biology—Food, digestion, and associated body systems; Human Biology—The skeletal-muscular system, the senses and human reproduction; and Animals, plants, and micro-organisms.
Chemistry	Classification of substances; Air, oxygen, carbon dioxide, and water; and Atomic structure, reactions, and compounds.
Physics	Force and energy; Heat, light, and sound; and Magnetism, electricity, and electronics.

During lower secondary, students learn to do the following:

- Use scientific knowledge to turn ideas into an investigable form and to plan accordingly;
- Decide the extent and range of data to be collected and the techniques, equipment, and materials to be used;
- Consider factors that need to be taken into account when collecting evidence;

- Make observations and measurements, including the use of data logging where appropriate;
- Critically consider, evaluate, and interpret data; and
- Organize and present information clearly and logically, using appropriate scientific terms and conventions, and using ICT where appropriate.

Many of the objectives of the syllabus are achieved by methodologies that support discovery through investigation. Time is also allowed for active student engagement in learning experiences, to help develop science process skills, better understanding of underlying science concepts, and higher-order skills associated with problem solving and the application of knowledge in new contexts. The syllabus in science provides opportunities for learners to develop thinking and decision-making skills that can be used in problem solving. Such skills can be developed through the systematic approach to investigation, which is a feature of science, and they can be easily transferred to other, non-scientific situations and contexts.

Teachers are encouraged to use a science-technology-society (STS) approach in their science instruction to facilitate student understanding of science and to link learning to everyday contexts and issues. While there is no explicitly prescribed STS content in the syllabus, many of the sub-topics and associated learning outcomes require appropriate links to everyday experiences (in areas such as health, diet, human development, and ecology) and to everyday examples of applications of science (such as in biotechnology, industry, medicine, energy conservation, and electronics).

Appropriate references to the work of prominent scientists and to modern scientific developments provide points of transference from school-based learning to general experience, making scientific phenomena more meaningful for the students.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Materials, Equipment, and Laboratories

No specific instructional materials or textbooks are prescribed for the teaching of mathematics or science at primary or lower secondary levels. At primary school, teachers are provided with guidelines on appropriate materials for mathematicsand science,and publishers are provided with specifications reiterating the importance of practical work and outlining principles for developing support materials (e.g., visual resources, textbooks, teachers' manuals, and assessment materials).[9, 10]

Teacher guidelines for mathematics at lower secondary, including examples of instructional planning for some topics, have been published to support the revised syllabus introduced in 2000.[11] In practice, teachers base instruction on commercially published textbooks, supplemented by past examination papers. In the case of science, students must complete a minimum of 23 mandatory experiments over a three-year period. As such, schools must have adequate laboratory space, apparatus, and chemicals to facilitate this requirement. While the Department of Education and Skills issues a list of the minimum resources needed to implement the practical work, the list is indicative only. Teachers can also access the National Council for Curriculum and Assessment's ACTION website (http://action.ncca.ie/), which demonstrates features of effective teaching and learning through the use of multimedia and includes some materials that support the teaching of mathematics and science.

Use of Technology

Technology use in fourth grade mathematics and science tends to focus on online interactive resources (games, video, and simulations to present and reinforce concepts). Other technology configurations are in use, such as visualizers and digital media tools, to assist with visualizing and presenting concepts. However, a recent study found that use of technology was a regular feature of only a minority of primary school mathematics lessons.[12] At lower secondary, online interactive resources, digital projectors, laptops, and other configurations such as visualizer and sensor technology are used in science lessons in some schools. Access to high speed broadband and greater access to technology in the classroom, alongside the development of ICT in the mathematics and science curriculum, is significantly influencing and gradually changing how teachers use ICT in the classroom and in their approach to accessing input from science and mathematics expertise online.

The mathematics curriculum provides for the introduction and use of calculators in mathematics from Grade 4 onward, by which time students should have acquired a mastery of basic number facts and a facility in their use. The curriculum highlights how students' understanding of the structure of number can be enhanced with a calculator through exploration of patterns, sequences, and relationships. The curriculum also encourages the use of calculators to help develop students' problem-solving skills, by allowing them to focus on the structure of a problem and exploring different methods to solve problems. In addition, the curriculum advises teachers to allow calculator use for the purpose of checking estimates, performing long and complex computations, and providing exact results to difficult problems. However, the curriculum stipulates that students need a sound understanding of numbers to make judgments about when it is appropriate to estimate, to calculate mentally, to make a calculation on paper, or to use a calculator for an exact result. Standardized tests for Grade 4 through 6 have specific directions for when a calculator can and cannot be used.

The science curriculum includes general statements on the use of ICT in primary school, noting that students' investigations and explorations can be enhanced through the use of ICT; for example, recording and analyzing information, simulating investigations and tests that support scientific topics, communicating scientific information and findings, working collaboratively on science projects with students in other schools, and in accessing and using a range of scientific and technological information.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Primary teachers are non-specialist teachers. Students are assigned specialist teachers for mathematics and science upon entering lower secondary education.

Homework Policies

There is no national homework policy. Almost all primary schools provide students from first to sixth grades with homework on four or five nights per week[13] and some also set a small amount of homework to students in Infant classes. Homework usually serves to consolidate and extend classroom learning. Post-primary schools are urged to develop homework and assessment policies, and there has been significant emphasis on assessment for learning strategies in teacher education in recent years. However, schools have considerable autonomy in such matters and there are no specific guidelines or directives given to schools regarding types or length of homework.

Teachers and Teacher Education

Teacher Education Specific to Mathematics and Science

Teaching in Ireland is an all-graduate profession. Primary teachers complete their initial teacher education either through a concurrent (3-year, full-time

Bachelor of Education degree) or a consecutive (18-month, post-graduate diploma in education) model. It has been proposed that the length of initial teacher education be increased to four years for the concurrent model and two years for the consecutive model. For post-primary teachers, the concurrent route to a teaching qualification is offered for a broad range of programs, typically those with practical, workshop, and laboratory elements. The post-primary consecutive route is a one-year post-graduate professional diploma in education which has been proposed to increase to a minimum of two years.

Prior to the recent publication of revised accreditation criteria for teacher education programs (2011),[14] requirements specific to the teaching of mathematics and science were not set out at any stage of the continuum of teacher education. At the primary level, some teachers will have chosen either mathematics or science as elective subjects for the academic component of their Bachelor of Education degree. However, as the same teacher generally teaches all subjects to their class, all primary school mainstream teachers are teachers of mathematics and science, and both subjects are integral parts of initial teacher education.

At the post-primary level, teachers of mathematics and science are expected to have relevant degrees. The consecutive model of pedagogical training is most common in these disciplines, a degree course followed by a Post-Graduate Diploma in Education. In some universities, a concurrent model is followed, with teaching practice occurring during at least two years of a four-year degree program.

Requirements for Ongoing Professional Development

Although teachers are expected to participate regularly in professional development, doing so is not currently compulsory. From September 2012, all newly-qualified teachers will need to complete a national induction program that will include specific components on the teaching of numeracy and on assessment.

The Professional Development Service for Teachers and the Special Education Support Service are lead agencies for professional development at both primary and post-primary levels. Other sources include a national network of Education Centers and appropriate groups, bodies, and institutions that offer professional development programs from which teachers can select courses appropriate to their needs.

At the primary school level, additional targeted training has been provided to teachers in the implementation of the revised curriculum of 1999, and in Maths Recovery in schools serving students from a socioeconomically deprived background.[15] In recent years, very substantial professional development has supported the new post-primary program, Project Maths, for all post-primary mathematics teachers. T4, the technology subjects support service, currently provides professional development to post-primary teachers of Design and Communications, Graphics, and Technology.

Monitoring Student Progress in Mathematics and Science

Section 22 of the Education Act requires schools "to regularly evaluate students and periodically report the results of the evaluation to the students and their parents." [16] More recent guidelines advise that schools report feedback to parents at least twice annually, including one written report.[17] There is evidence that a significant minority of schools do not provide adequate feedback to parents on a regular basis.[18, 19] At the primary level, school assessment approaches include the use of teacher questioning and observation, conferencing, and student self-assessment. Changes made in 2007 require schools to administer standardized tests in English and mathematics to students at two points: the end of first grade or the start of second grade, and at the end of fourth grade or the start of fifth grade. In practice, annual administration of standardized mathematics tests to all students from first through to sixth grade is almost universal. Individual schools choose their own assessment instruments, with the proviso that standardized tests have been normed for an Irish population and are consistent with the Primary School Curriculum. The *National Strategy to Improve Literacy and Numeracy* (published in 2011) proposes improved reporting to parents and requires that, from 2012, all primary schools report annually to the Department of Education and Skills the aggregated standardized test results of students at three points of the primary school cycle—second, fourth, and sixth grades. There is no intention to publish data from individual schools or to make it possible for the data to be used for the compilation of league tables.

Although Ireland does not operate a national mandatory system of assessment for primary schools, it monitors standards through the regular assessment of reading and mathematics performance of students in a representative sample of schools. Every five years, the Educational Research Centre conducts national assessments of reading and mathematics on behalf of the Department of Education and Skills. The main functions of the national assessments are to assess national standards, identify factors related to performance on the tests, and inform policy. Almost 8,000 students from second and sixth class took part in the most recent survey in 2009.

At the primary level, classroom tests in mathematics include multiplication table tests, commercially produced mental-arithmetic tests, teacher-designed tests, and problem-solving activities. Classroom assessment tests in science primarily comprise pen-and-paper tests that test content knowledge. Standardized tests are available for mathematics but not for science. At post-primary level, students take teacher-made assessments at the end of most terms. These assessments are generally in written form in mathematics, with some elements of practical work being assessed in science. It is normal for report cards, with grades and teacher comments, to be issued after such assessments. The DES's recently published literacy and numeracy strategy proposes mandatory use of standardized tests in the second year (Grade 8) of post-primary school.[20] At the end of lower secondary school, all students take formal state examinations in mathematics (at higher, ordinary, or foundation level). The almost 90 percent of students who choose science as a subject are also examined, at higher or ordinary level, with 35 percent of the total grade allocated for students' completion of a range of experiments and developing a portfolio of work.

Impact and Use of TIMSS

Ireland has not participated in TIMSS since 1995. There have been no formal studies of the impact of participation in TIMSS, but it is likely that certain changes can be attributed, at least partially, to participation. TIMSS contributed to the thinking behind the current primary school curriculum in mathematics and science, begun in the early 1990s. Possibly as a consequence of Ireland's only average performance on science, science was given a more distinct role in the current primary school curriculum. Also, TIMSS strongly influenced the three most recent national assessments of mathematics conducted at the primary level in Ireland.[21, 22, 23] This influence is apparent in the frameworks used to underpin the assessments, the style of test items, and the range of questionnaires administered. Further, the methodologies used by the IEA in both TIMSS and PIRLS have influenced how statistical analyses were conducted and results reported.

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Israel

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Introduction

Overview of the Education System

The education system in Israel is centralized under the supervision of the Ministry of Education, which determines the national curricula, including a compulsory core curriculum, and implements national and international educational testing policies. The K–12 education system consists of schools grouped into three levels: preprimary education (ages 3–6), primary (elementary) education (Grades K–6 for students ages 6–12), and secondary education including lower secondary (Grades 7–9 for students ages 12–15) and upper secondary (senior-high) education (Grades 10–12 for students ages 15–18).[1] Education is compulsory for students ages 3–18, but this requirement is being implemented gradually and is currently fully implemented only for ages 5–16.

Almost all schools are public. A small percentage of schools, particularly at the primary level, are special education schools, but most special education classes are integrated into regular schools. Schools in the Jewish and Arab sectors are divided first by language (Hebrew and Arabic) and then into different supervision frameworks representing different cultural and religious sub-sectors in Israel. For the Jewish sector, this includes secular supervision, religious supervision, and ultra-orthodox supervision, with separate supervisory bodies for the Arab, the Bedouin, and the Druze populations. Each of the supervision frameworks comprises different content and a different proportion of religious and cultural studies. However, at both primary and lower secondary levels, the mathematics curriculum and the science and technology (S&T) curriculum do not have special tracks and serve all students equally.[a] Hebrew and Arabic language supervision is centralized.

Languages of Instruction

Hebrew and Arabic are the two official languages of Israel. Hebrew is the main spoken language, widely used in business, government, academia, and media.

a This chapter compiles information from both official curricular sources and from personal communication with the Chief Inspector of Science and Technology Studies and the Chief Inspector of Mathematics Studies.

Other languages associated with recent waves of immigration, such as Russian and Amharic, also are spoken in Israel.

Currently, there are approximately 1.5 million students studying in K–12 classes in Israel. In Jewish-sector schools, Hebrew is the language of instruction and English is studied as a second language, usually from the third or fourth grade. Arabic is studied in lower secondary school as a third language, and is an elective major in high school. In Arab-sector schools, Arabic is the language of instruction, Hebrew is studied as a second language, and English is studied as a foreign language, usually from the third or fourth grade. The curricula for mathematics and for science and technology are written in Hebrew and translated to Arabic. All learning materials that are written in Hebrew must be translated to Arabic so that students in Hebrew-speaking schools and students in Arabic-speaking schools receive similar content. National tests are written in Hebrew and translated to Arabic, and international tests are translated from English to both Hebrew and Arabic.

Because Israel is a country of immigrants, special attention is paid to immigrant students. According to policy, new immigrant students receive special instruction in Hebrew as a second language for approximately four years to support their integration into regular classroom instruction conducted in Hebrew. Further assistance is provided according to individual student needs.

Mathematics Curriculum in Primary and Lower Secondary Grades

Both the primary and lower secondary mathematics curricula in Israel have gone through intensive revision during recent years. In 2002, a committee was appointed to examine the teaching of mathematics at all grade levels and to recommend improvements.[2] The committee identified several deficiencies related to mathematics teaching: a lack of sufficient attention to solving word problems, a tendency toward narrowing the curriculum only to topics appearing on the matriculation examinations, and a lack of sufficient geometry instruction (compared to algebra) in lower secondary school. In addition, the committee referred to ethnic as well as socioeconomic differences between subpopulations in Israel as indicators of low achievement. At approximately the same time that the committee's recommendations were published, other committees were appointed to examine pedagogical approaches advocated in learning materials. The committees concluded that the most common instructional approach emphasized arithmetic skills but did not focus on mathematical reasoning;

moreover, the curricula for primary and secondary mathematics education were not linked to each other in a learning progression.[3, 4] Lastly, the committees found the conditions for teaching mathematics to be inadequate: classrooms were crowded and populated with students at disparate levels, teachers lacked discipline-specific knowledge, and there were not enough supervisors in the field.

In 2003, an intervention program, the Quantitative Reasoning Program, was implemented in about half of lower secondary 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 student ability to cope with mathematical problems that require the integration of skills learned in other subjects. The intervention program went through several cycles of revision, and was the first step in the development of a new curriculum for primary schools introduced in 2006.

The 2006 update to the mathematics curriculum for primary schools focused on generating a link between primary and lower secondary schools and alignment with the TIMSS frameworks.[5, 6] The goal of the revised curriculum for primary grades is for students to learn basic concepts and structures in the numbers and geometry domains, as well as develop mathematical skills and abilities, such as developing number sense, gaining geometric insight, learning computational skills, using mathematical tools to solve word problems, and having conceptual understanding and knowledge of mathematical language. Attaining mathematical knowledge is considered a cumulative process, dependent on student ability to grasp mathematical concepts and link these concepts to other school subjects and the real world. The development of mathematical literacy is stressed. 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 (addition, subtraction, multiplication, division), fractions (arithmetic operations, common denominators, decimal equivalents), percentages, and proportion.

- Geometry and Measurement—Geometric shapes (two-dimensional shapes, such as polygons, triangles, squares, rectangles, and three-dimensional shapes, such as rectangular prisms); measurement of length, area, volume, angles, etc.; transformations and symmetry; properties of quadrilaterals; circles; classification of three-dimensional shapes; and computation of area and volume.

In 2009, a new mathematics curriculum was developed for lower secondary schools, which integrates the mathematical knowledge learned in primary school with new and more advanced topics, and uses a spiral approach to curricular planning to expand on topics previously taught. The spiral sequencing allows students to continually return to basic ideas as new subjects and concepts are added over the course of a curriculum in order to solidify understanding over periodic intervals. The curriculum merges three domains—numbers, algebra, and geometry—and cultivates student ability to use multi-domain problem-solving methods. It also emphasizes the development of mathematical literacy. The new curriculum allocates at least 150 instructional hours to mathematics at each grade and includes recommendations concerning the allocation of instructional hours for each topic to assist teachers in planning.

The main mathematics topics are distributed over the three grade levels of lower secondary school, as presented in Exhibit 1 (subjects for Grade 8 are described in greater detail).

Science Curriculum in Primary and Lower Secondary Grades

Since the early 1990s the science curriculum in Israel at both the primary and lower secondary levels has focused on science and technology literacy. It has included the mastery of significant facts, concepts, principles, and theories related to each scientific discipline; a grasp of science and technology processes and their impact on society; and, above all, the ability to use science and technology knowledge for personal and societal needs. Beyond introducing key concepts and ideas of science and technology, the general objectives of the curriculum are to highlight the similarities and differences between the two disciplines; indicate their contributions and limitations; and develop students' intellectual competencies, such as inquiry and decision-making skills, as well as performance skills for design and practical problem-solving.

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 quality of life; the world of living organisms; ecosystems and environmental quality; the Earth and the universe; and information and communication.[7] Each domain is divided into sub-domains that contain a detailed list of specified 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 each topic.

Exhibit 1: Mathematics Topics, Grades 7–9

	Content Domain	Percent of Curriculum	Topics
Grade 7	Numbers	20%	Negative numbers, fractions and decimals, and the Cartesian plane.
	Algebra	45%	Patterns, algebraic expressions, and equations.
	Geometry	35%	Formulas for perimeter and area (rectangles, triangles, parallelograms, rhombi, and trapezoids), volume and surface area (cubes and boxes), and concepts related to angles.
Grade 8	Numbers	32%	Ratio and proportion, percentage, descriptive statistics, chance and probability, real numbers, and square roots. Ratio is a major theme later in Grade 8 and includes a variety of topics (scale, proportion, similarity of triangles, the slope of a straight line, linear functions of the form $y = mx$, percent, relative frequency).
	Algebra	48%	Algebraic expressions; linear functions; solving equations, inequalities, and simultaneous equations; and using linear functions to solve problems. The concept of linear functions is used as a foundation for studying solution methods for linear equations, systems of linear equations with two unknowns, inequalities, equations with absolute values, and word problems whose solutions involve these methods.
	Geometry	20%	Geometric shapes and Euclidean geometry including triangle congruence, properties of isosceles triangles, similar triangles, the Pythagorean theorem (including its use in the coordinate plane), theorems, and proofs. The key concepts taught in eighth grade geometry are isosceles triangles and similar triangles, which serve as a basis for further studies of deductive proof in geometry. Attention is directed mainly toward enhancing student awareness of the correctness and logic of statements of congruence and similarity, and why the conditions set forth in congruence and similarity theorems are necessary and sufficient.
Grade 9	Numbers	44%	Fractions in algebraic expressions, multiplication, exponentiation, quadratic functions, and quadratic equations.
	Algebra	10%	Chance and graphs.
	Geometry	46%	Euclidean geometry, including triangles (isosceles, equilateral, and right triangles), quadrilaterals, and circles.

The syllabus does not define the sequence of the topics, and teachers are encouraged to decide on suitable sequencing to meaningfully connect topics, based on their specific pedagogical beliefs and their unique educational contexts.

In addition to the content domains, the curriculum also promotes the development of cognitive and performance skills woven into the content. The four overlapping groups of skills highlighting different aspects of scientific practice are processing information and information handling skills, inquiry and problem-solving skills, performance skills, and communication skills.

In 2009, a national program aimed at strengthening science and technology education (Strategic Plan to Strengthen Science and Technology) was established.[8] Through this program, the curriculum for lower secondary schools was revised and an extensive rewriting and adaptation of the instructional materials began. One of the reasons for the curriculum revision was the gap between the intended and implemented instructional hours, which made it almost impossible for teachers to cope with the curriculum and resulted in certain topics, such as earth science, being neglected. For example, the curriculum allocated six instructional hours a week to science and technology; however, in practice, they were only taught 3–4 hours per week. As part of the adaptation process, the technology discipline was separated from the scientific disciplines and topics in each discipline were clearly defined.

In 2010, the revised lower secondary school science and technology curriculum was implemented as an experiment, with formal approval being granted at the end of 2011. Building on the primary school syllabus, the curriculum for science and technology in lower secondary school imparts basic concepts, modes of thought, and inquiry and problem-solving strategies in science and technology. The curriculum builds a foundation for students who will major in other disciplines and forms a basis for advanced science and technology studies for students choosing to major in these disciplines. The syllabus defines the sequence of the topics that are organized in a spiral teaching sequence and aligned with the TIMSS frameworks. The curriculum allocates at least 120 instructional hours in Grade 7 and at least 150 instructional hours in Grades 8 and 9 to science and technology. Earth science is part of the geography curriculum and includes 60 instructional hours in Grade 8.[9]

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 therefore, many end their science studies in the ninth grade. Currently, attempts are being made to ensure that every student will continue to study science and technology beyond ninth grade and take at least the basic level of a matriculation examination in an area of science (for more on the matriculation examination, see Monitoring Student Progress, below).

The main topics in the science curriculum are distributed over the three grade levels of lower secondary school as presented in Exhibit 2 (subjects for Grade 8 are described in greater detail). Earth science is taught in geography and covers the following topics: astronomy, geology (internal forces) and geomorphology (external forces), climate and weather, and Earth's resources.[10]

Exhibit 2: Science Topics, Grades 7–9

	Content Domains	Percent of Curriculum	Topics
Grade 7	Materials	38%	Properties and uses, and physical changes in matter.
	Energy	12%	Forms and transformations.
	Cell Structure and Function	7%	
	Systems and Processes in Living Things	27%	
	Ecosystems	17%	
Grade 8	Electricity and Magnetism	17%	Current and electrical charges; factors affecting the intensity of current in an electrical circuit; energy transformation in electrical circuits; electricity and safety; renewable and nonrenewable sources of energy; and energy production, usage, and ecological cost.
	Forces and Motion	10%	Interaction, forces, and changes; daily use of forces (simple machines and levers); and movement and speed.
	Materials	30%	Elements, compounds, and mixtures; elements, the atomic model, and the periodic table; chemical reactions; mixtures; conservation of matter; energy transformations; materials (use and ecological cost).
	Cell Structure and Function	7%	Genetic material (DNA) in cells, and its function and organization in chromosomes; cell division, mitosis and its importance in life processes, and meiosis and its importance in reproduction processes; relationships between structure and function in cells; sperm and egg cells; and differentiation of cells.
	Systems and Processes of Living Organisms (Reproduction)	20%	Types of reproduction; fertilization; development of embryos and offspring; and maturation and finding mates.
	Ecosystems	17%	Interactions between living organisms; materials and energy transitions; ecological balance and human impact; and biological diversity.

	Content Domains	Percent of Curriculum	Topics
Grade 9	Cell Structure and Function	20%	
	Systems and Processes in Living Organisms	20%	Nutrition and heredity.
	Ecosystems and Chemistry	10%	Human health, quality of life, and the impact of substance abuse on individuals, society, and the environment.
	Physics and Technology	40%	Energy and technological systems and the impact of energy uses on individuals, society, and the environment.
	Investigative and Problem-solving Project	10%	Projects are in one of the content domains, at teacher discretion.

The curriculum also defines cognitive skills as well as inquiry and problem-solving skills. Cognitive skills include strategic thinking, logic and critical thinking, reflective thinking, probability thinking, and creative thinking. These are subdivided into the following: locating, collecting, and transferring data; processing and representing data; and written and oral presentation of knowledge. Inquiry and problem-solving skills incorporate processes characterizing scientific and technological endeavors, such as planning an investigation, information management, conducting data analysis, and drawing conclusions.

Instruction for Mathematics and Science in Primary and Lower secondary Grades

Mathematics is taught in the primary grades (Grades 1–6) for five hours weekly and in lower secondary schools (Grades 7–9) for four to five hours weekly. Science is taught weekly at the primary level for two to three hours (in the state-religious and the state-secular schools, respectively), and for four to five hours in Grades 7–9. Earth science is to be taught weekly for two hours in Grade 8, and most schools adhere to this instruction. Under ultra-orthodox supervision, instructional hours are not specified. Schools allocate hours to provide additional instruction to small groups of students, often to support students with learning difficulties.

Instructional Materials, Equipment, and Laboratories

Every year, the Ministry of Education publishes a list of specifications for materials and equipment for mathematics and science and technology instruction. Textbooks and other learning materials are developed by not-for-profit organizations and universities, or by commercial agencies and publishers, but must be approved by the Ministry of Education. The process of approval of instructional materials involves review by anonymous experts of pre-published versions to evaluate the compatibility of the content of the instructional material to the discipline at hand, the pedagogical and didactical aspects, the syllabus, and the curriculum policy. Although the criteria are curriculum-based, the approved materials are quite varied, and teachers can choose their own textbooks.

To support teachers in adopting the revised lower secondary school science and technology curriculum, extensive development of teaching materials was carried out by experienced teachers on behalf of the science and technology administration in the Ministry of Education, under the supervision of instructional material experts. The resulting teaching materials are inquiry-based activities within science topics designed to accomplish a variety of teaching goals, accompanied by a teaching guide and evaluation tools. The materials were sent to lower secondary schools throughout the country and also are available on the Internet.

Beginning in the third grade, the Ministry of Education recommends teaching science and technology subjects in a laboratory setting. In many schools, the laboratory is a multipurpose room suitable for investigations in both science and technology. Following the science and technology education reform, steps were also taken to equip laboratories with materials.

Use of Technology

Most schools have computer laboratories, but the systematic use of computers in classrooms is still not common and typical lessons in primary and lower secondary schools are not computer-supported. Nevertheless, most students are computer literate due to the wide use of personal computers at home. Students also are expected to use their personal computers at home to communicate with their teachers and peers and to prepare assignments.

As part of professional development in ICT, teachers are able to participate in a variety of courses to acquire computer and technology skills. However, most teachers do not integrate the use of computers into their teaching; they use computers for communication purposes only.

A national program initiated in 2011, Adapting the Educational System to the 21st Century, aims to create learning environments in which technology supports innovative pedagogy and 21st century skills. In addition, professional development workshops have been created to promote teachers' technological pedagogical content knowledge to enable them to implement computer-based learning environments, to use instructional materials effectively, and to create a learning continuum from the classroom to the home.

Establishing a suitable infrastructure (i.e., computers, laboratories, and a shift toward using them as part of routine instruction) became a priority as a result of instructional reforms in mathematics, science, and technology. In mathematics, the use of computers is limited; but calculators are commonly used, beginning in the lower secondary grades. Graphing calculators are not available. In science, the use of computers is part of teaching, especially for literature searches, data processing, simulations, and models.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Recruiting teachers with an academic background in mathematics and the science disciplines for teaching in primary and lower secondary schools continues to be a challenge despite special efforts.

The Ministry of Education recommends that science and technology, studied from Grade 3, be taught by specialist science teachers: those with an academic background in a scientific discipline or who have specific training in science education. Similarly, mathematics, which is studied from the first grade, should be taught by specialist mathematics teachers: those with an academic background in mathematics or who have specific training in mathematics education. Current primary school teachers can qualify as science or mathematics teachers through extensive professional development programs offered through colleges of education. In spite of the recommendation and efforts to professionalize teaching, a shortage of suitable candidates for available positions, mostly in primary schools, prevents the realization of these recommendations. To date, about 50 percent of primary school teachers have a scientific background that meets the recommended criteria. Science is usually taught by homeroom teachers in Grades 1–2, by generalist teachers in Grades 3–4, and by specialist science teachers in Grades 5–6.

In lower secondary schools, all mathematics and science teachers hold the required qualification: either a bachelor of science or higher academic degree, or a bachelor of education with specific training in mathematics or science education. Most teachers also hold a teaching license; in most cases, science teachers hold a teaching license in biology or in chemistry.

In each school, one of the qualified mathematics teachers and one of the qualified science and technology teachers serve as the subject coordinators, instruct the other teachers on their team, and participate in determining the school learning programs and testing policy within each subject. Visits to schools are conducted every two weeks by pedagogical instructors—experienced teachers selected to help other teachers stay current in their teaching practice.

Homework Policies

There is no official policy concerning homework, although it is assigned on a regular basis in mathematics. Homework in science focuses on projects.

Teachers and Teacher Education

Initial teacher education takes place in schools of education at universities and in colleges of education. Teacher education programs combine disciplinary and pedagogical content, typically comprise a four-year program plus a one-year supervised induction program, and result in a bachelor's degree in education. The pedagogical component of teacher education includes educational studies, research methodology, and pedagogical studies which include a supervised practicum. Since 2006, 24–30 credit hours per year of pedagogical studies are required to complement the 60 credit hours per year of disciplinary studies.[11] The requirements for obtaining a teaching license include earning a teaching certificate and an academic degree as well as successfully completing the induction year.

Requirements for Ongoing Professional Development

The organizational bodies responsible for professional development are located at institutions of higher education, universities, teachers' colleges, and in professional development centers. All professional development courses currently offer credits that translate into salary increases for teachers. There are four types of professional development: Ministry-of-Education-initiated group professional development intended to facilitate policy implementation; task-oriented professional development that prepares staff for certain positions (e.g., principals, coordinators, and leaders); school-based professional development aimed at responding to school needs; and personal professional development that provides professional enrichment and further education.

Among the courses and workshops offered by universities and colleges are intensive courses for current primary teachers to obtain mathematics, science and technology, and geography teaching qualifications.

Since 2009, in accordance with the New Horizon educational and professional national reforms, all primary and lower secondary school teachers are required to participate in professional development for 60 hours a year with at least half of the time dedicated to their subject domain. In addition, monthly institutional-professional development training is provided for each school (28 hours per month), with the principal and management staff deciding the content and type of training. This institutional professional development includes between two and five subject areas for each school and two to three subject areas for each teacher. With the 2009 curricular reforms, additional in-service training was provided to support teacher adoption of the new mathematics and science curricula. Intensive institutional professional development programs are provided for primary school mathematics and science teachers. For geography, there are national conferences and computerized continuing education programs.

Monitoring Student Progress in Mathematics and Science

Student progress in mathematics and science, as in other subjects, is monitored by schools' internal and external evaluation systems. School-based assessments consist of specific formative and summative tasks chosen by teachers. The schools' internal evaluation system is administered by the school staff, and is the central component of the teaching-learning-assessment process. The evaluation is based on the schools' internal tests and assessment of student activities and projects. Student report cards are distributed at least twice a year and student achievement is reported using numerical grades (in a scale up to 100), accompanied by descriptive grades (i.e., excellent for 95–100; very good for 85–95 and so on). Most primary schools use descriptive grades accompanied by narrative evaluations up to Grade 4.

There is also a national feedback-monitoring mechanism that conducts regular external examinations of a national sample of students, which tests different subject areas of the curriculum in depth. The National Authority for Measurement and Assessment in Education (known by its Hebrew acronym, RAMA) was founded in 2005 to addresses the need for professional measurement, evaluation and assessment in the education system.[12] The ideology at the heart of RAMA's activities rests on two principles: an assessment of learning and a mixture of professional solutions that integrates different components of measurement and assessment.

The first Israeli national assessment (*Meitzav,* a Hebrew acronym for Growth and Efficiency Measures of Schools) was introduced in 2002.[13] In 2007, a new format was designed by RAMA in collaboration with the Ministry of Education, and in consultation with school principals and teachers. The new format integrates internal and external assessment and promotes the implementation of a culture of measurement for learning—measurement that is intended to support the continual improvement of learning through the alignment of learning goals with the school vision, and based on the understanding that tests are not a goal in and of themselves but rather an instrument for learning.

Meitzav includes student achievement tests and questionnaires about school climate and the pedagogical setting (administered to principals, teachers and students). Schools are tested (External *Meitzav*) once every two years in mathematics, first language (Hebrew or Arabic), English, and science and technology. The External *Meitzav* provides a picture of student achievement in these four subjects at the system level, and informs professional bodies in the ministry and other decision-makers about educational policy issues, including issues related to school climate and pedagogical settings. The Internal *Meitzav* is administered in the intervening years and provides information to principals and teachers about education at the individual school level as a tool for planning and allocating resources, realizing student potential, improving the pedagogical climate, and enhancing the school instructional system.

The *Meitzav* assessments in mathematics, first language (Hebrew or Arabic), English, and science and technology are administered to students in the fifth and eighth grades. There also is a test of native language (Hebrew or Arabic) in the second grade. The assessments are designed to align with subject curricula and aim to examine the extent to which students in primary and lower secondary schools have achieved the level required of them according to the outcomes described in the curricula.

The matriculation examinations (*Bagrut*) are regarded as the official tests to measure the results of the 13 years of compulsory schooling in Israel.[14] The examination process is governed by the Ministry of Education and creates a standard measure of student knowledge throughout the country. Every high school student has the option of taking the matriculation exams. These high-stakes examinations, taken in three stages at Grades 10–12, cover all subject areas taught in secondary school, and are usually used to determine access to higher education.

The *Bagrut* tests reflect the subject matter studied in Grades 10–12. The subjects studied in these grades are divided into core subjects and elective subjects, both of which are compulsory. Core subjects include mathematics and English as a foreign language. In the Hebrew sector, Hebrew (grammar and writing), literature, bible studies, history, and civics are mandatory. In the Arab sector the equivalent mandatory subjects are Arabic (grammar and literature) and history, civics, and Hebrew. Students have over 50 elective subjects to choose from, drawn from the disciplines of science, the humanities, social sciences, and the arts. Students also can choose to specialize in any compulsory core subject and be tested at the highest level of learning in that subject. This includes Hebrew and literature for the Jewish sector and Arabic and Hebrew for the Arab sector. Students who wish to major in science can choose physics, chemistry, biology, earth sciences, environmental sciences, agriculture, biotechnology, or computer sciences. Laboratory examinations constitute a part of the five learning units in most of the science majors.

The final score obtained in a subject is a combination of a student's average grade on his or her school examination (upon which the yearly grade is based) and the grade obtained on the state examination. Students whose combination of subjects does not render them eligible for a matriculation certificate are awarded a School Completion Certificate; however, students may complete the required examinations to acquire a Matriculation Certificate even after graduation.

Impact and Use of TIMSS

Israel has been participating in TIMSS study cycles at the eighth grade since 1999, with 1999 as the country's baseline year. During this period, and in particular during the past three years, the curricula for both mathematics and science for primary and lower secondary schools were revised and new standards were adopted. In mathematics, domains learned at primary and lower secondary school have been aligned with each other, with the aim of generating a link between the primary and lower secondary curricula. In science, topics were reorganized to fit the designated instructional hours and a teaching sequence was determined. One result of updating the curricula and adopting international standards is alignment with TIMSS.

TIMSS provides valid and reliable information about the Israeli education system from an international perspective as well as a national one. This information is of great importance to policymakers who want to know about the strengths and weaknesses of the education system in Israel through objective comparison with other education systems around the world. Furthermore, participation in international studies allows Israel to learn about new and current approaches to teaching mathematics and science, and to examine its own curricula in relation to curricular approaches in other countries.

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Italy

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Introduction

Overview of the Education System

The Italian Constitution requires the state to offer a public school system to all citizens and permits the co-existence of state and non-state schools.[1, 2] Overall responsibility for education lies with the Ministry of Education (MIUR—Ministero dell'Istruzione, dell'Università e della Ricerca), which operates centrally and is responsible for organizing the various education levels, public schools, and curricula. At the local level, regional school offices delegate responsibilities to provincial and municipal authorities. Schools have autonomy with regard to didactics, organization, research, experimentation, and development.[3]

The Italian school system is organized into preprimary education followed by two education cycles. Preprimary education enrolls children ages 3–6 and is not compulsory. The first cycle of education is compulsory and is divided into primary school (five years) and lower secondary school (three years). A school-leaving examination is required for entry into upper secondary school. A single curriculum, established at the national level, is common to all schools.

The second cycle of education lasts five years, the first two of which are compulsory, and consists of upper secondary school and vocational education and training. Lycee, technical institutes, and vocational training institutes comprise upper secondary school and are governed by the state. Vocational education and training consists of certified education and training agencies which are governed by regional governments.[4] In upper secondary education, MIUR establishes the basic curriculum for all upper secondary school tracks (general, vocational, and technical) and also provides guidance on teaching methods.

Mathematics is a fundamental discipline common to all schools, with some differences in the curriculum taught in the various tracks. The study of sciences is divided into separate school subjects (e.g., chemistry, physics, and biology), with some differences according to the track chosen by the student; not all science subjects are taught in all types of schools.

Languages of Instruction

Italian is the official language of Italy and it also is the language of instruction. The state recognizes and safeguards twelve linguistic minorities found in certain regions of the country, but only four of these are legally recognized: French (in the region of Valle d'Aosta), Slovenian (in Friuli-Venezia Giulia); German (in the province of Bolzano), and Ladin (in Trentino-Alto Adige and the autonomous province of Trento).[5, 6] In these regions, students can attend schools where the language of instruction is that of their respective linguistic minority.[7]

Mathematics Curriculum in Primary and Lower Secondary Grades

In 2007, MIUR published the *Indications for the Curriculum*, which schools use as a frame of reference for designing and implementing primary and lower secondary curricula. Acting autonomously, schools develop competencies and learning objectives aligned with these curricula.[8]

Specifically, learning objectives for primary schools correspond to expectations for students to achieve by the end of the third year and fifth years of primary education.[9] Exhibits 1 and 2 summarize the objectives and expectations of the mathematics curriculum in primary schools.[10, 11]

Exhibit 1: Mathematics Objectives and Expectations at End of Grade 3

Content Area	Objectives and Expectations
Numbers	Count objects or events, either aloud or mentally, in increasing or decreasing order, and in intervals of two and three;
	Read and write whole numbers accounting for place value;
	Compare and sort numbers and plot them on a number line;
	Mentally perform simple operations with whole numbers and verbalize calculation procedures;
	Know multiplication tables for numbers up to 10;
	Perform operations with whole numbers with common written algorithms; and
	Read, write, and compare decimal numbers (written as unit-less numbers, in monetary units, or as simple measurements), represent them on a number line, and perform simple addition and subtraction.

Content Area	Objectives and Expectations
Space and Shapes	Report the position of objects in physical space, both with regard to the student him or herself and to other people or objects, by using appropriate terms (above and under, in front of and behind, left and right, and inside and outside); Perform a simple procedure starting from a verbal description or drawing; Construct and execute simple algorithms; Recognize, name, and describe geometric figures; and Draw geometric shapes and construct material models in space, using appropriate instruments.
Relations, Measurements, Data, and Chance	Classify numbers, figures, and objects according to one or more properties using context-appropriate representations; Explain the criteria used for making assigned classifications; Represent relations and data with diagrams, charts, and tables; and Measure segments using a ruler or arbitrary units, and link measurement practices to knowledge of numbers and operations.

Exhibit 2: Mathematics Objectives and Expectations at End of Grade 5

Content Area	Objectives and Expectations
Numbers	Understand division of natural numbers with remainders, and identify multiples and divisors of a number; Read, write, and compare decimal numbers and perform arithmetic operations with confidence; Choose a method of calculation (mental, written, or calculator) based on the context of a problem, and estimate the result of an arithmetic operation; Understand the concepts of fraction and equivalent fractions; Use decimal numbers, fractions, and percentages to describe everyday situations; Interpret negative integer numbers within concrete contexts; Represent numbers on a number line and use graded scales in science and technology contexts; and Understand systems of numerical notation that are or were used in places, times, and cultures other than the present.
Geometry	Describe, classify, and identify significant elements and symmetries of geometric figures; Reproduce a figure, based on a description and using appropriate instruments (e.g., graph paper, ruler, compass, squares, and geometry software); Use the Cartesian plane to locate points, and construct and use material models on a plane and in space as a support to visualizing them in the abstract; Recognize rotated, translated, and reflected figures; Reproduce a figure according to scale (e.g., on graph paper); Determine the perimeters of figures; and Determine the areas of rectangles, triangles, and other figures by decomposition.

Content Area	Objectives and Expectations
Relations, Measurements, Data, and Chance	Represent relations and data and use the representations to obtain information and make judgments and decisions;
	Use notions of arithmetical mean and frequency;
	Represent the structure of problems with graphs and tables;
	Understand the common units of measurement for lengths, angles, areas, volumes, time intervals, masses or weights, and use them to make measurements and estimates;
	Convert from one unit of measurement (including monetary units) to another;
	Consider a pair of events, explain which is the more likely, or recognize that both events are equally probable; and
	Recognize and describe patterns in a sequence of numbers or figures.

The objectives and expectations of the mathematics curriculum in lower secondary education are summarized in Exhibit 3.[12]

Exhibit 3: Mathematics Objectives and Expectations at End of Grade 8

Content Area	Objectives and Expectations
Numbers	Perform arithmetic operations with and compare natural numbers, whole numbers, fractions, and decimals mentally or by means of common written algorithms, calculators, and calculation tables, and evaluate which instrument is the most suitable in context;
	Make estimates for the result of an arithmetic operation and check the plausibility of a calculation;
	Represent numbers on a number line, use graded scales in science and technology contexts, and describe ratios and quotients using fractions;
	Use equivalent fractions and decimal numbers to denote the same rational number in different ways, and understand the advantages and disadvantages of different numerical representations in context;
	Calculate percentages, and interpret a percentage increase in a given quantity as a multiplication by a number greater than 1;
	Identify multiples and divisors of natural numbers, and multiples and divisors common to several numbers; and understand the meaning and utility of the lowest common multiple and greatest common divisor in mathematics and in other practical contexts;
	Find prime factors of natural numbers and understand their uses;
	Use positive whole exponents correctly;
	Use properties of exponents to simplify calculations and notation;
	Understand square root as the inverse operation of squaring a number;
	Estimate square roots using multiplication;
	Perform simple mental calculations using associative and distributive properties to simplify arithmetic operations;
	Express a sequence of operations with simple algorithms; and
	Correctly use rules governing order of operations both with and without brackets.

Content Area	Objectives and Expectations
Geometry	Reproduce figures and geometric shapes from descriptions, using suitable tools (e.g., ruler, square, compass, and geometry software); Represent points, segments, and figures on a Cartesian plane; Know the definitions and significant properties of figures (e.g., triangles, quadrilaterals, regular polygons, and circles); Describe complex figures and geometric constructions; Recognize similar plane figures in various contexts and reproduce figures to scale; Understand the Pythagorean theorem and its applications in mathematics and the real world; Calculate the areas of simple figures by breaking them down into more elementary figures (e.g., triangles); Estimate the area of a figure consisting of curves by rounding; Understand π (e.g., as the area of a circle with a radius of 1), and some ways to approximate it; and understand formulas used to find the area of a circle and the length of its circumference; Represent three-dimensional objects and plane figures in various ways (e.g., drawings on a plane); Visualize three-dimensional objects starting from two-dimensional representations; Calculate volumes of the most common three-dimensional figures and estimate volumes of everyday objects; and Solve problems using geometric properties of figures and solids.
Relations and Functionsz	Construct, interpret, and transform formulas containing variables to express relationships; Express proportionality using equivalent fractions (and vice versa); Use the Cartesian plane to represent relations and functions, and to understand such as $y=ax$, $y=a/x$, $y=ax^2$, $y=2n$ and their graphs; Link concepts of slope and proportionality; and Explore and solve problems by using first-degree equations.
Measurements, Data, and Chance	Represent data sets in several forms, including software spreadsheets; Compare data to inform decisions using frequency and relative frequency distributions, as well as the notions of arithmetical mean and median; Identify elementary events in simple random situations, discuss ways to assign a probability to them, calculate the probability of an event, and break it down into separate elementary events; and Recognize pairs of complementary, incompatible, or independent events.

Science Curriculum in Primary and Lower Secondary Grades

According to guidelines provided by MIUR, the science curriculum for primary school is organized by identifying content to be taught by the end of the third year (Grade 3) and by the end of the fifth year (Grade 5).[13] There is no specific curriculum for the end of the fourth year. The objectives and expectations of the science curriculum in primary schools are summarized in Exhibits 4 and 5.[14, 15]

Exhibit 4: Science Objectives and Expectations at End of Grade 3

Content Area	Objectives and Expectations
Experiment with Objects and Materials	Identify qualities and properties of objects and materials, through interactions and manipulations, and characterize their transformations, recognizing both the relative magnitudes to be measured and also the qualitative relations between them (e.g., as X increases, Y increases or decreases); Cause transformations by varying modalities, and construct scenarios to account for the transformations (e.g., "what happens if …", "what happens when …"); and Recognize "families" of occurrences and regularities (e.g., "the same thing happened as…") within fields of experience.
Observing and Experimenting in the Field	Observe, describe, compare, and correlate elements of the surrounding environment, such as distinguishing plants and animals or soils and waters, understanding similarities and differences, and making classifications according to specified criteria; Become familiar with atmospheric phenomena (e.g., wind, clouds, and rain) and with the periodicity of celestial phenomena (e.g., day and night, the sun's path in the sky, the moon's phases, and the seasons); Recognize elements constituting a natural ecosystem or one that is controlled and changed by human actions, and understand relationships among the elements (e.g., though explorative trips, caring for small animals in class, planting and tending a small vegetable garden, and constructing food networks); and Recognize the intraspecific and interspecific diversity of living things and the similarities and differences between plants, animals, and other organisms.
Man, Living Things, and the Environment	Perceive the presence and functioning of internal organs and their arrangement within the main systems (e.g., respiration and circulation) and create simple models; Identify relationships between structures and functions in observed and observable organisms, and know that unique features of living organisms are adaptations to their environment; and Observe and interpret environmental changes caused by the seasons and also by man's actions.

Exhibit 5: Science Objectives and Expectations at End of Grade 5

Content Area	Objectives and Expectations
Objects, Materials, and Transformations	Construct models of fundamental geometric and physical concepts (e.g., lengths, angles, surfaces, volume, weight, temperature, force, and light);
	Shift from sequencing on the basis of a property (e.g., sorting objects by their increasing weight according to the increasing extensions of a spring) to constructing, calibrating, and using common tools (e.g., springs for measuring weight, and everyday containers for measuring volume);
	Shift from making initial measurements in arbitrary units to conventional units; investigate the behavior of everyday materials in everyday contexts by experimenting to establish their properties (e.g., composition, hardness, transparency, elasticity, and density);
	Produce heterogeneous mixtures and solutions, and changes in state and combustion; and interpret observed phenomena in terms of variables and relationships between them, expressed in graphic and arithmetic form;
	Recognize invariance and conservation in everyday transformations;
	Recognize the plausibility of early qualitative macroscopic and microscopic models of physical and chemical changes; and
	Begin to experience the concepts of irreversibility and energy.
Observing and Experimenting in the Field	Make frequent and regular observations with the naked eye, a magnifying glass, and a stereomicroscope, with classmates and alone, in order to analyze a part of the environment over time (e.g., a tree, a hedge, or part of a garden) and to identify elements, connections, and changes; and investigate ground structures, relationships between soils and living things, and water as a phenomenon and a resource;
	Distinguish and restore environmental components by exploring the surrounding natural and urban environments;
	Understand diversity among ecosystems (natural or human-modified ones, either locally or in other geographical areas);
	Identify the intraspecific and interspecific diversity of living things and their behaviors (e.g., differences and similarities between plants, animals, fungi and bacteria);
	Use classification as a static and dynamic interpretative tool of similarities and differences; and
	Continue to observe the daytime sky and night sky on a monthly and yearly basis, build three-dimensional models of astronomical systems, and interpret the observed movements of astronomical bodies from various reference frames in connection with the historical evolution of astronomy.
Man, Living Things, and the Environment	Study human perceptions (e.g., brightness, sound, touch, and balance) and their biological bases; investigate the relationships between sense organs, overall physiology, and habitat; and compare various animals belonging to different groups, such as worms, insects, and amphibians;
	Compare human sensory observations with readings from artificial sensors, and understand how sensors are used in everyday life;
	Continue the study of the life processes of organisms, and compare human reproduction to animal and plant reproduction;
	Respect one's body as an unique entity (e.g., with respect to health education, nutrition, and health risks); and
	Observe and interpret environmental changes, including global changes, and particularly consider the results of human modifications to the environment.

The objectives and expectations of the science curriculum in lower secondary education are summarized in Exhibit 6.[16]

Exhibit 6: Science Objectives and Expectations at End of Grade 8

Content Area	Objectives and Expectations
Physics and Chemistry	Understand physical concepts such as velocity, density, concentration, force and energy, and heat and temperature; Perform experiments and make comparisons; Gather and correlate data with appropriate instruments, and build concept maps, models, and other formal representations of physical systems; and Understand the concept of chemical transformation through practical and diversified experiences, focusing on common substances (e.g., reactions of acids and bases with metals, calcium carbonate solution, neutralization reactions, and the combustion of different materials).
Astronomy and Earth Science	Interpret models of celestial phenomena by observing the day and night sky throughout the year; Observe and interpret latitude and longitude, the cardinal compass points, reference frames and movements of the Earth, day and night, phases of the moon, eclipses, and observed movements of planets and constellations; Build in-depth knowledge of geological history as well as ideas and interpretative models of the Earth's structure through field work and other concrete experiments of rocks, minerals, and fossils; Consider the ground as an ecosystem and a resource, and also understand that its formation is the result of weather and life on Earth (e.g., erosion-transportation-settlement processes); and correlate this knowledge with evaluations of the geomorphological, hydrological, volcanic, and seismic risks to the local region and understand the consequent planning of safeguards against these risks; and Understand the fundamental mechanisms of global changes in natural systems and the Earth as a whole, and the role of human action in these changes.
Biology	Identify the interconnectedness and change processes of living things by introducing the concept of microscopic organization at the cellular level (e.g., cell respiration, nutrition, photosynthesis, growth and development, and co-evolution among species); identify the unity and diversity of living things by performing activities at school, in the laboratory, in the field, and in science and nature museums; and understand the rationale of broad classification schemes; Recognize that adaptations are interlinked with Earth's and man's history; Compare ideas of natural and human history; Learn the proper management of one's body, how to interpret the states of wellness and illness that can derive from its alterations and experiencing sensuality in a balanced or unbalanced manner; and learn how to make decisions to deal with the risks connected with poor nutrition, smoking, and drug abuse; and Conduct an analysis of environmental risks and sustainable decisions (e.g., with regard to transportation, city organization, agriculture, industry, waste disposal, and lifestyle); and understand the fundamental function of biodiversity in environmental systems.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Materials, Equipment, and Laboratories

Primary and lower secondary schools are generally equipped with instructional materials and tools to support teaching the various school subjects; nonetheless, the textbook is still the main instructional tool used. New textbooks are adopted every five years in primary schools and every six years in lower secondary schools. Schools also are required to adopt textbooks which publishers have pledged not to alter for five years (except for those sections which require necessary updating), preferably choosing books also available in digital or mixed format. Beginning in the 2011–12 school year, schools will be required to adopt textbooks usable exclusively in a downloadable or mixed media format. Textbooks are chosen by the school's various subject teachers and then adopted by the teachers' committee after hearing the opinions of interclass or class councils and parent representatives. Primary school textbooks are free of charge for families, and MIUR establishes a limit for expenditures for lower secondary school student textbooks.[17, 18] Schools are encouraged to set up laboratories and other specially equipped spaces such as libraries, gymnasiums, and science and music labs; and schools are responsible for purchasing instructional materials, instruments, and equipment, according to each school's budget.

Use of Technology

Since the late 1990s, the ministerial curricula for using new information and communications technologies (ICT) in schools has been promoted and implemented, and many primary and secondary schools have ICT laboratories today. Computer science currently is a school subject in both primary and secondary schools.[19] However, although calculator and computer use should be actively encouraged beginning in the early years of primary school (i.e., to verify the accuracy of calculations worked out mentally or by written algorithms, and to explore numerical phenomena), in current practice calculators seldom are used during lessons.[20]

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Teachers of all school levels currently receive their initial training at universities. Primary school teachers are generalists, even if they acquire responsibility for a certain disciplinary field. Secondary school teachers are specialists and, starting from the lower secondary level (Grade 6), it is mandatory to have a degree related to the subject taught. In order to teach mathematics or science, teachers must have either a mathematics or science degree (e.g., biology, life science, or geology), respectively.

Homework Policies

Homework may be assigned to students of all schools and grades.[21, 22] It is current practice for primary school teachers to assign homework only to students who are on a part-time and not full-time schedule.

Teachers and Teacher Education

As of the 2011–12 academic year and following the reform of initial teacher education introduced with Decree 249/2010, a five-year university degree in education, including a 600-hour internship, is required in order to teach in preprimary and primary schools. A five-year university degree, including a one-year active internship in a school under the guidance of a teacher-tutor, is required to teach in secondary schools.[23]

These education programs include the acquisition of English language skills to intermediate proficiency (the B2 examination level) and of digital technology skills. Specifically, prospective teachers learn to use multimedia for representing and conveying knowledge, and understand and use more general digital content, simulation environments, and virtual laboratories. In addition, they develop competencies that facilitate including students with special needs.

Universities also offer in-service teacher education for the new skills required by a changing school system. Teachers' professional profiles currently include competencies in documentation and evaluation, along with disciplinary, psycho-pedagogical, methodological, organizational, relational, and research skills. In addition, universities allocate additional funds to educational-methodological and evaluation research in order to develop innovative processes for improving student learning.[24]

Monitoring Student Progress in Mathematics and Science

At both primary and lower secondary education levels, periodic and annual assessments of student learning are carried out by teachers, and students receive numerical grades on a ten-point scale based on these assessments.[25] At the primary level, student grades are accompanied by written analytical assessments. In daily practice, individual teachers have the autonomy to determine how students are assessed, and student evaluation at all school levels is conducted through oral, written, graphical, and practical testing (depending on the subject).

For each period of evaluation, every school independently drafts a student evaluation report on each student's progress in each area of study. Every teacher has a register in which students' attainment levels and absences are recorded. At the end of the school year, grades are copied onto a report card. The Student's Portfolio, introduced by the 2003 school reform, records each student's individual competencies and personal and educational history, and contains a section for evaluation and direction of future studies.[26] The use of the Student's Portfolio is optional.

Students move from primary to lower secondary school on the basis of a positive evaluation at the end of their final year of primary education (Grade 5); there is no state examination at this level. In lower secondary schools, at the end of each school period (i.e., every 3–4 months) and at the end of each school year, the teachers of each class meet in a class council and assign final grades to each student. Grades are presented by the teachers of each discipline to the class council, and are discussed and approved by majority vote. A grade of six out of ten (equivalent to "satisfactory") is the minimum passing grade.

Since 2004, the National Institute for the Educational Evaluation of Instruction and Training (INVALSI), through the National Service for the Evaluation of Education and Training (SNV), has sought to improve the quality of the education system through national and international assessments.[27] For the 2010–11 school year, this external evaluation of student performance involved second- and fifth-year primary school students; in 2010–11, it also assessed first- and third-year lower secondary school students.[28]

At the end of lower secondary school (Grade 8), all students take a state examination. If they obtain an overall grade higher than six out of ten, they obtain the certificate needed to enter upper secondary education. At this stage, each school prepares its own final examination in mathematics and science (on the basis of the student curriculum). As of the 2008–09 school year, the state examination also includes the INVALSI tests for Italian and mathematics.[29]

Students also receive periodic and annual evaluations of their conduct, which also is expressed as a numerical grade on a ten-point scale. If the class council gives a conduct grade lower than six, the student can not advance to the next grade; if such a grade is given in Grade 8, the student cannot take the final lower secondary school examination.

Students with learning difficulties identified before the fourth grade have personalized study plans and engage in remedial activities in class during normal lesson times. For students younger than eighth grade who have learning difficulties, MIUR establishes personalized study plans and afternoon remedial courses that the student would take with their own class teacher.

Impact and Use of TIMSS

Results from international surveys in which Italy has participated, including TIMSS and PISA, have helped spur the National Operational Programs (PON) to set up a project (the Plan for Information and Training on the OECD–PISA Survey and Other International and National Research) to improve school service quality in four Italian regions: Calabria, Campania, Puglia, and Sicily. The project has two strategic objectives: increasing student reading comprehension and mathematical skills, and reducing the dropout rate. By focusing attention on theoretical and methodological aspects of evaluating learning, the project aims to improve the assessment results of students of the four regions.

In order to improve Italian student performance in international surveys, during 2010–12, informational and training sessions have been offered to teachers of Italian, mathematics, and science at every school type and level, as well as to teachers of adult education. Another aim is to spread an evaluation culture in primary and secondary schools by providing teachers with diversified tools and materials such as tests and scoring guidelines.[30]

Suggested Readings

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Japan

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Introduction

Overview of the Education System

The Fundamental Law of Education,the basis for post-World War II education in Japan, was enacted in 1947 and amended in 2006.[1] This law establishes the basic principles of Japanese education and provides students with equal opportunities to receive a free, compulsory education for nine years. It is the foundation of all education-related laws in Japan, including the School Education Law and the Social Education Law.[2, 3]

The Ministry of Education, Culture, Sports, Science, and Technology (MEXT) is the administrative body responsible for school education, and all educational activities come under its supervision. Local bodies establish and maintain virtually all primary and lower secondary schools and are accountable to a prefectural or municipal board of education. MEXT supervises and subsidizes local boards of education.

Both public and private institutions exist at all levels of the academic hierarchy. The federal government bears most of the expense for 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 contributions from businesses. However, national and prefectural governments do provide financial assistance toward maintaining and improving private schools. Throughout Japan, 81.2 percent of kindergarten students, 1.1 percent of primary school students, 7.1 percent of lower secondary school students, and 29.7 percent of upper secondary school students are enrolled in private schools.[4]

Three types of institutions provide public preprimary education: kindergartens, day-care centers, and centers for early childhood education and care. Kindergartens enroll children ages 3–6 and are supervised by MEXT. Kindergarten educational programs last from one to three years. Day-care centers enroll children ages 0–6 and are under the jurisdiction of the Ministry of Health, Labor, and Welfare. Centers for early childhood education and care are a new type of preprimary institution designed to promote cooperation between kindergartens and day-care centers. The federal government authorized these centers in 2006, and MEXT has collaborated with the Ministry of Health, Labor, and Welfare to improve the new system.

Education in Japan follows a 6–3–3 pattern: six years of primary school, three years of lower secondary school, and three years of upper secondary school. Some students attend six-year secondary schools that combine lower secondary education with both general and specialized upper secondary education. Introduced into the school system in April 1999, these comprehensive secondary schools are designed to focus on the diverse needs of secondary school students. Of students attending these comprehensive schools, 31.9 percent are enrolled in private six-year secondary schools.

Compulsory education consists of six years of primary education and three years of lower secondary education, and almost all children ages 6–15 are enrolled in school. In 2010, 98.0 percent of this age cohort went on to upper secondary school, and 50.9 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 three years, while part-time and correspondence students can take longer. In 2010, about 96 percent of students in upper secondary schools were enrolled full-time.[6]

In public primary and lower secondary schools, there is no official policy on within-school streaming, and students are not tracked. From primary 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. However, beginning in seventh grade, schools may offer several optional subjects for interested students to take. At the upper secondary level, schools place students into tracks according to their entrance examination achievement levels, offering courses geared toward differing abilities and interests. In Grades 11 and 12, schools offer several different curriculum options in mathematics and science.

Upper secondary education is divided into two main streams: general secondary education and specialized secondary education. In 2010, 72.3 percent of students in upper secondary schools were enrolled in the general stream,[7] which provides general academic preparation. The specialized stream provides vocational and other classes for students who are preparing for a specific career, with subjects such as agriculture, business, fisheries, home economics, nursing, information technology, social work, physical education, music, art, science, mathematics, and English.

Under Japan's curricular reform, the national curricula, called the *Courses of Study,* have been revised eight times since their implementation in 1947, with the goal of keeping up with societal changes over the years and the needs of each age group. Also, in general, there have been changes in the number of class hours. The revised *Course of Study for Elementary Schools* was announced on March 2008 and fully implemented in April 2011.[8] However, some parts of the new curricula for mathematics and science were partially implemented during a transition period from April 2009 to March 2011. Similarly, the revised *Course of Study for Lower Secondary Schools* was announced in March 2008 and also fully implemented in April 2012,[9] but some parts of the new curricula for mathematics and science were partially implemented during a transition period from April 2009 to March 2012.

Languages of Instruction

Japanese is spoken by the overwhelming majority of Japanese people, and therefore, Japanese is the language of instruction. According to 2009 population data, Japan's population was 127.51 million.[10] The majority of the inhabitants are Japanese. In addition, the population includes Koreans (0.4%), Chinese (0.5%), Brazilians (0.2%), and other minority groups. Recently, registered foreigners and foreigners with residency status have gradually increased in number and account for 1.6 percent of all residents in Japan.[11] In some regions (such as in Brazilian communities), education is provided both in Japanese and Portuguese.

Mathematics Curriculum in Primary and Lower Secondary Grades

The national mathematics standards, objectives, and content for primary, lower secondary, and upper secondary education are presented in the *Courses of Study.*[12, 13, 14]

Mathematics is a required subject in primary, lower secondary, and the first year of upper secondary school. Beginning with the 1998 revision of the mathematics curriculum, mathematics activities have been part of the objectives of the curriculum for every grade. In addition, enjoying mathematics is an objective at the primary and lower secondary level, while fostering creativity in mathematics is an objective at the upper secondary level.

The mathematics curriculum consists of three parts: overall objectives for the level (primary, lower secondary, or upper secondary), objectives and content for each grade, and syllabus design. Methods and materials also are specified to some extent in the objectives and contents for each grade, as well as in the construction of teaching plans and remarks about content. In addition, the primary school curriculum prescribes the standard numbers of class periods per year for mathematics. All schools are obliged to address all points relating to the content of mathematics. 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 methodology and teaching framework; and a plan for the evaluation of learning.

In the 2008 revision of the curriculum, the mathematics content in Grades 1–6 is composed of four areas: Numbers and Calculations, Quantities and Measurements, Geometrical Figures, and Mathematical Relations. At the lower secondary school level, the mathematics content is composed of four areas: Numbers and Algebraic Expressions, Geometrical Figures, Functions, and Making Use of Data.

The overall objectives for mathematics at the primary school level (Grades 1–6) are to use mathematical activities to accomplish the following:[15] to help students acquire basic and fundamental knowledge and skills regarding numbers, quantities, and geometrical figures; foster students' ability to think logically and express themselves clearly about everyday matters; help students find pleasure in mathematical activities and appreciate the value of mathematical approaches; and encourage students to use mathematics in both their daily lives and their learning. Exhibit 1 presents the objectives and content for mathematics in fourth grade.[16]

Exhibit 1: Mathematics Objectives and Content, Grade 4

Content Area	Objectives and Content
Numbers and Calculations	Understand decimal numbers and fractions and that integers can be expressed using the decimal system; understand round numbers and appropriate contexts for using them; understand division and extend the ability to divide integers accurately; consolidate the ability to calculate integers and extend the ability to use these calculations; deepen understanding of decimal numbers, including adding, subtracting, multiplying, and dividing decimal numbers and using these calculations; deepen understanding of fractions, including adding and subtracting fractions with the same denominators and using these calculations; and add and subtract using a *soroban* (Japanese abacus).
Quantities and Measurements	Understand the meaning of units of measurement for area and use calculations to determine areas of geometrical figures; and understand the meaning of units and measurements for angles and measure angles.
Geometric Figures	Understand plane figures (e.g., parallelograms, rhombuses) and solid figures (e.g., rectangular parallelepiped) by observing their elements and exploring the relationships among those elements; recognize the elements and positional relationships of two-dimensional and three-dimensional geometrical figures through activities such as observing and drawing these figures.
Mathematical Relations	Represent and explore the relationships between two numbers or quantities as they vary simultaneously; understand the algebraic expressions that represent the relationships between numbers or quantities and use these expressions; deepen understanding of the properties of the four basic operations; and gather and organize data according to purpose, represent data clearly by using tables and graphs, and explore the features of data.

The overall objectives for mathematics at the lower secondary level (Grade 7–9) are to use mathematical activities to do the following: help students deepen their understanding of fundamental concepts, principles, and rules regarding numbers, quantities, and geometrical figures; help students acquire skills in mathematical processing and representation so that they can develop their ability to analyze and represent phenomena mathematically; help students enjoy mathematical activities and appreciate the value of mathematics; and encourage students to apply their mathematical understanding and ability when they think and evaluate.[17] Exhibit 2 presents the objectives and content for mathematics in eighth grade.[18]

Exhibit 2: Mathematics Objectives and Content, Grade 8

Content Area	Objectives and Content
Numbers and Algebraic Expressions	Develop the ability to discern algebraic relationships in concrete phenomena, represent these relationships in algebraic expressions using letters, and interpret these expressions; understand how to calculate the four fundamental operations with expressions using letters; and solve and interpret simultaneous linear equations with two variables.
Geometric Figures	Through activities such as observing, manipulating, and experimenting, discover the properties of basic plane figures and verify those properties based on the properties of parallel lines; understand the congruence of geometrical figures and verify the properties of geometrical figures based on the conditions for congruence of triangles; and develop the ability to think and represent logically.
Functions	By exploring concrete phenomena, understand linear functions and develop the ability to discover, represent, and analyze functional relationships.
Making Use of Data	Develop the ability to understand and use probability through exploring uncertain phenomena and be able to use it to analyze and represent data.

Science Curriculum in Primary and Lower Secondary Grades

The national science standards, objectives, and content for primary, lower secondary, and upper secondary education are presented in the *Courses of Study*.[19, 20, 21]

Science teaching begins in the third grade and is a required subject throughout compulsory education. The science curriculum consists of three parts: overall objectives for the level (primary, lower secondary, or upper secondary), objectives and contents for each grade or section, and syllabus design. All schools are obliged to address all points relating to the content of science. Each school must formulate an overall plan for science that includes descriptions of the following: objectives and content; qualities, abilities, and attitudes to be fostered; learning activities; teaching methodology and teaching framework; and a plan for the evaluation of learning.

The overall objectives for science in Grades 3–6 are as follows: enable students to become familiar with nature and to carry out observations and experiments from their own perspective; help students develop their problem-solving abilities; nurture students' affection for the natural world; help students develop a realistic understanding of natural phenomena; and encourage students to embrace scientific perspectives and ideas.[22]

The objectives for science in fourth grade are to help students do the following: [23]

- Develop perspectives and ideas about the properties and functions of objects by investigating air, water, changes in states of matter, and electrical phenomena in relation to the functions of power, heat, and electricity and by exploring the identified problems and making learning materials with interest; and
- Develop a loving and protective attitude toward living things; and develop perspectives and ideas about the structure of the human body, the activities of animals, the growth of plants, meteorology, and the movement of the moon and stars by investigating them in relation to movement, seasons, temperature, and time and by exploring the identified problems with interest.

The science curriculum in fourth grade is divided into two areas: matter and energy, and life and the Earth. Exhibit 3 presents the content covered in each area.[24]

Exhibit 3: Science Content, Grade 4

Content Area	Topic	Content
Matter and Energy	Properties of Air and Water	Help students develop their ideas about the properties of air and water by exploring changes in volume and pressure when air and water are compressed in a closed space.
	Metal, Water, Air, and Temperature	Help students develop their ideas about the properties of metals, water, and air by exploring the changes that occur when metals, water, and air are heated and cooled.
	Function of Electricity	Help students develop their ideas about electricity by exploring the functions of a dry battery and photocell when they are attached to small bulbs and motors.
Life and the Earth	Structure and Movement of the Human Body	Help students develop their ideas about the relationship between the structure and movement of the human body by exploring the movement of bones and muscles, by observing the movement of humans and other animals, and by using teaching materials.
	Seasons and Living Things	Help students develop their ideas about the relationship between seasons and animal activities and plant growth by finding and raising familiar animals and plants and by exploring the activities of animals and the growth of plants in different seasons.
	Weather Conditions	Help students develop their ideas about weather conditions and the change of water in the natural world by observing temperature changes over the course of a day, the process of water changing to vapor, and by exploring changes in weather and temperature and the relationship between water and vapor.
	The Moon and Stars	Help students develop their ideas about the characteristics and movement of the moon and stars by observing them and by exploring the position of the moon and the color, brightness, and position of stars.

The overall objectives for science at the lower secondary level (Grades 7–9) are as follows: enable students to take an active interest in natural things and phenomena and to carry out observations and experiments with a sense of purpose; help students to develop the ability to perform investigations scientifically and to develop a positive attitude about these investigations; help students to deepen their understanding of natural things and phenomena; and help students to develop scientific ways of looking at and thinking.[25]

The science curriculum at the lower secondary level is divided into two fields: physical science, and biology and earth science. The objectives for physical science at Grade 8 are to enable students to do the following: [26]

- Take an active interest in things and phenomena related to matter and energy; acquire methods for discovering patterns; and acquire methods for resolving problems through activities that explore these things and phenomena.

- Acquire skills for observation and experimentation by making observations and conducting experiments about physical events and phenomena and develop the ability to analyze, interpret, and express the results; understand familiar physical phenomena, electric currents and their use, and motion and energy; and develop scientific ways of looking at and thinking about these events and phenomena.
- Acquire skills for observation and experimentation by making observations and conducting experiments on chemical substances and associated phenomena and develop the ability to analyze, interpret, and express the results; understand the role of chemical substances in daily life; understand chemical changes and atoms (molecules), and chemical changes and particles; and develop scientific ways of looking at and thinking about these things and phenomena.
- Increase awareness about the connections between scientific and technological developments and human life through activities that explore matter and energy; and through these activities, develop an attitude of scientific ways of thinking and a comprehensive view of nature.

The objectives for biology and earth science at Grade 8 are to enable students to do the following:

- Take an active interest in living things (including the natural things and phenomena surrounding them); acquire methods for discovering diversity and patterns; and acquire methods for resolving problems through activities that explore these natural things and phenomena.
- Acquire skills for observation and experimentation by making observations and conducting experiments on living things and phenomena and develop the ability to analyze, interpret, and express the results; understand the lives and varieties of living things; and develop scientific ways of looking at and thinking about these living things and the continuity of life and phenomena.
- Acquire skills for observation and experimentation by making observations and conducting experiments about geological events and phenomena and develop the ability to analyze, interpret, and express the results; understand the composition and changes of the Earth, the climate and its changes, and the Earth and the universe; and develop scientific ways of looking at and thinking about these events and phenomena.

- Develop respect for life and an attitude of contributing to the conservation of the environment through activities that explore living things and phenomena in nature surrounding them; and through these activities, develop a comprehensive view of nature.

Exhibit 4 presents the content covered in the two science fields—Physical Science, and Biology and Earth Science—during eighth grade.

Exhibit 4: Science Content, Grade 8

Content Area	Topic	Content
Physical Science	Electric Currents and Their Uses	Understand the function of electric currents and the relationship between electric currents and voltage by observing and conducting experiments; and develop elementary ways of looking at and thinking about electric currents and magnetic fields in connection with everyday life and society.
	Chemical Changes, Atoms, and Molecules	Understand the changes in substances and their quantitative relationships with regard to chemical combinations, decomposition by observing and conducting experiments; and develop ways of looking at and thinking that attempt to connect these changes to atomic and molecular models.
Biology and Earth Science	The Lives of Animals and the Transitions of Living Things	Through observation, understand that the bodies of living things are made up of cells; understand the body structure and functions of animals by observing and conducting experiments; deepen recognition of the diversity of animal life; and understand the transitions in living things that occur over time.
	Weather and Its Changes	Discover the relationship between meteorological elements and weather changes by observing local weather; and deepen recognition of the mechanisms and patterns of climatic phenomena.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

The school year begins April 1 and ends March 31. School holidays include national holidays, Saturdays and Sundays, and three long vacations. Most primary and secondary schools are in session for 35 weeks of the year.

Exhibit 5 shows the total number of class periods per year and the number and percentage of yearly class periods that are spent on mathematics and science in primary and lower secondary schools. A class period is 45 minutes in primary school and 50 minutes in lower secondary school. (In Grades 1 and 2, Life and Environmental Studies is taught instead of science and social studies.)

Exhibit 5: Yearly Instructional Time in Mathematics and Science in Japan by Grade

Grade	1	2	3	4	5	6	7	8	9
Class Period Totals	850	910	945	980	980	980	1,015	1,015	1,015
Mathematics	136	175	175	175	175	175	140	105	140
Percent of Total Class Periods	16%	19.2%	18.5%	17.9%	17.9%	17.9%	13.8%	10.3%	13.8%
Science			90	105	105	105	105	140	140
Percent of Total Class Periods			9.5%	10.7%	10.7%	10.7%	10.3%	13.8%	13.8%

Instructional Materials, Equipment, and Laboratories

Textbooks must be authorized by MEXT, if MEXT does not already own the copyright of these textbooks. All mathematics and science textbooks are written and edited by private publishers and approved by MEXT. Textbook publishers submit a draft of their proposed textbook to MEXT. The ministry's Textbook Authorization Research Council, composed of university professors and teachers, checks the draft against the *Courses of Study* and proposes revisions if necessary. Once a textbook has been revised and approved by MEXT, it is placed on a list of authorized textbooks.

Local boards of education then choose textbooks from this authorized list for use by the schools under their jurisdiction. Groups of cities or towns usually join together to form adoption areas that select textbooks for compulsory education, choosing on the basis of teacher suggestions. At the upper secondary levels, individual schools choose textbooks from those authorized by MEXT.

The science curriculum contains statements about the use of experiments. Specifically, in primary school, teachers should give consideration to consolidating scientific knowledge and concepts, as well as developing scientific perspectives and ideas, by providing opportunities for experiments, observations, scientific experiences, and experiences in nature. Primary schools also should give consideration to facilitating student-run enrichment activities that enable students to conduct observations and experiments and to use scientific terms and concepts when they explain natural events and phenomena. In addition, primary schools should give consideration to seeking actively to partner and collaborate with museums and science centers.

The science curriculum states that in lower secondary school, teachers should emphasize experiments and observations. Students can use both the school itself and the local environment as the basis for scientific research on observable phenomena. This emphasis on experimentation and observation exposes students to fundamental concepts and methods that they can build upon throughout their scientific education. This emphasis also encourages students to develop a positive attitude toward science.

Use of Technology

It is essential to cultivate student ability to use information in order to respond independently to an advanced information and communication network society. The 2004 e-Japan Priority Policy Program Plan required all classrooms to have access to computers and the Internet by 2005. As of March 1, 2011, Japanese schools had one computer for every 6.6 students, and 82.3 percent of normal classrooms had a LAN (local area network) connection.[27]

The most recent *Courses of Study* encourage information education. The *Course of Study for Elementary Schools* contains statements about acquiring the basic skills of using computers, making an appropriate use of information in each subject, and acquiring the ethics of information use. *The Course of Study for Lower Secondary Schools* contains statements about enriching learning activities so that students can make proactive use of computers and about emphasizing instruction related to the ethics of information use.

The mathematics curriculum contains statements about using calculators and computers. Specifically, it says that in primary school, students should use computers when necessary to enrich their sense of numbers, quantities, and geometrical figures and to improve their ability to represent data by using tables and graphs. In lower secondary school, teachers should consider when it would be appropriate for students to use *soroban* (Japanese abacuses), calculators, computers, and information and communication networks to improve their learning—in all content areas but particularly for instruction related to numerical calculations and for activities like observation, manipulation, and experimentation.

The science curriculum also contains statements about using computers and other technology. In primary school, teachers should select appropriate devices, such as computers or audio-visual equipment, to use in their learning activities (e.g., performing experiments, cultivating plants, raising animals), as well as when they create instructional materials. Students should gain proficiency in using and manipulating this technology. In lower secondary school, teachers should consider that students proactively use computers and information and communication networks in all content areas, but particularly when searching for information, processing data, observing, and taking measurements while conducting experiments.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

In the Japanese educational system, the majority of primary schools have classroom teachers who teach all subjects, including mathematics and science, while almost all lower secondary schools have specialist teachers for mathematics and science beginning in seventh grade.

Homework Policies

There is no government policy on homework.

Teachers and Teacher Education

Teacher Education Specific to Mathematics and Science

In Japan, becoming a public school teacher requires graduating from a ministry-approved university teacher education program and then obtaining a teaching certificate for a particular type of school (primary, lower secondary, or upper secondary). During teacher education programs, university students must earn a required number of course credits and conduct a pre-practicum in a school for several weeks, supervised by the school teacher.

The board of education for each prefecture or metropolitan district confers these teaching certificates. Teachers also must pass a teacher employment examination administered by the local board of education and then complete a one-year conditional employment period. During this period, new teachers receive a broad spectrum of training conducted by the local board.

Requirements for Ongoing Professional Development

In 2003, Japan instituted a new professional development system under which all teachers with ten years of experience receive training, according to their individual abilities and aptitudes, in topics such as course instruction and student guidance. Local boards of education offer courses and workshops to improve teachers' instructional abilities and develop educational knowledge that is useful for instruction. Lesson study (*Jyugyou kenkyu*) is a popular type of training to improve teaching skills, especially for primary school teachers.

Monitoring Student Progress in Mathematics and Science

Since the 1980s, three types of large-scale assessments have been held in Japan: the Assessment of Implementation of Curriculum, the Assessment of Specific Issues of Education, and the National Assessment of Academic Ability.[28] The

National Assessment of Academic Ability has been held every year since 2007. Each assessment has different aims, as shown in Exhibit 6.

Exhibit 6: Assessment of Education for Primary and Secondary School Students Since the 1980s

Title	Aim	Grade, Survey Method	Subjects	Date
The Assessment of Implementation of Curriculum	Collect data for revising the curriculum and improving methods of instruction	Grades 5, 6, 7, 8, and 9 Sample of Students	Japanese/Social Studies/Mathematics/ Science *English: Only for lower secondary school	Before revising the curriculum and after the revised curriculum is implemented.
The Assessment of Specific Issues of Education	Collect data about specific issues in education	Depends on the subject Sample of Students	Japanese/ Mathematics (2004) Science / English (2005)	Every year since 2004.
The National Assessment of Academic Ability	Review achievement and issues in education	Grade 6 and 9 Complete Population (2007–2009) Sample of Students (2010–)	Japanese/ Mathematics * Science will be added in 2012	Every April since 2007 except 2011 because of the earthquake.

In primary and lower secondary schools, student progress is reported to parents at the end of each school term in a report card that provides both norm-referenced and criterion-referenced evaluations. In mathematics and science, teachers use the following four aspects of criterion-referenced evaluation: interest, eagerness, and attitude toward mathematics or natural phenomena; mathematical or scientific thinking; expression and processing; and knowledge and understanding.

Students in Japan also take entrance examinations for both upper secondary schools and universities. Almost all prefectural boards of education administer the entrance examination for prefectural and municipal upper secondary schools, which students enter in ninth grade. These entrance examinations cover several subjects, including mathematics and science.

To enter national, prefectural, municipal, and most of the private universities, all applicants must take an entrance examination called the National Center Test for University Admissions. This test covers several subjects, including mathematics and science, and is administered by the National Center for University Entrance Examination, an incorporated administrative agency. Applicants must also pass specific entrance examinations administered by individual universities.

Impact and Use of TIMSS

Japan has previously participated in TIMSS 1995, 1999, 2003, and 2007. Japan's participation in TIMSS, as well as PISA, is an activity governed by the educational policies of MEXT. Several research studies have used TIMSS results to discuss improvements in teaching and learning.[29] Moreover, TIMSS results have been used as reference materials for discussions about educational reforms. The fact that TIMSS' National Study Center is located at the National Institute for Educational Policy Research (NIER) facilitates further sharing of the results with policy makers. In particular, NIER curriculum specialists in mathematics and science can easily access the results.

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Jordan

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Introduction

Overview of the Education System

Jordan's education system is responsible for preparing Jordan's citizens to achieve their aspirations and meet the challenges of the future. To best accomplish these goals, the system has evolved over the past decade. The most important recent development has been the extension of the compulsory, free, basic education cycle from nine to ten years.

A central principle of Jordan's educational policy is centralizing the general planning and follow-up of the education system while decentralizing its administration.[1]

Within the Ministry of Education, the Board of Education determines the curriculum and the ministry's divisions for monitoring, finance, and inspection have responsibility for auditing the school system.[2, 3]

The Ministry of Education has been providing high-quality curricula, textbooks, and teacher manuals that meet international standards. These materials include improved content and form, emphasize critical and creative thinking as well as problem-solving skills, and link content to life experiences. The materials also help students apply information in their academic and everyday lives, as required by the present era of technical and scientific progress.

Jordan's education system consists of the following cycles:

- Kindergarten—This 2-year cycle begins at age 4. It includes preschool and is noncompulsory. Almost all schools are either privately operated or run by volunteers.
- Basic Education—This 10-year cycle begins at age 6. Basic education is compulsory, and the curriculum is the same for all students and evaluated annually. In Grades 8–10, students are classified and enrolled in different types of lower secondary education 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 Jordanian society. At the end of basic education (Grade 10), students are classified into two major streams: the comprehensive (academic and vocational) secondary educational stream, and the applied secondary educational stream. The comprehensive program ends with the General Secondary Education Certificate Examination in the following specializations: an academic sub-stream (including scientific and literary specializations) and a vocational sub-stream (including industrial, commercial, agricultural, nursing, hotel management, and home economics). The applied secondary educational stream provides vocational education and training for skilled labor to meet the needs of society.

Educational statistics indicated that the number of students enrolled in schools in the 2010–11 school year was 1,652,094.[4] The net enrollment rates were 37 percent in kindergarten, 98 percent in the basic cycle, and 76 percent in the secondary cycle.

The Ministry of Education has plans to expand and improve the quality of preschool education and to encourage the private sector to establish Kindergartens, indicating the importance of preprimary education. The Education Reform for the 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. One component of the project promotes learning readiness in early childhood education and emphasizes targeted approaches to improving the availability and quality of early childhood learning opportunities. The project will directly assist in implementing a comprehensive approach to improving the scope and quality of essential early childhood services.[5, 6]

Within its capabilities, the Ministry of Education has established a number of kindergartens, particularly in remote and underprivileged areas, in order to achieve the following goals:

- Provide children with an adequate educational environment and care for well-balanced educational growth;
- Help children acquire positive attitudes toward school for a smooth transition from home to school;
- Develop good health practices;
- Improve children's social relationships; and
- Enhance children's positive attitudes and love for school life.

One of the Ministry of Education's projects involves developing and updating curricula, and focusing on achieving excellence in mathematics and science. Special e-math and e-science projects are in place. E-math projects receive funding from the CISCO Learning Institute, and e-science projects are funded by the private sector, specifically the Fastlink Corporation.

Languages of Instruction

Jordan's official language is Arabic, which also is the main medium of instruction. However, English is commonly used and spoken in public and private schools in Jordan. French is the medium of instruction in some private schools.

Mathematics Curriculum in Primary and Lower Secondary Grades

Jordan has undergone several educational reforms since 1989, in which curricular revisions were a major component. In the latest project, Education Reform for the Knowledge Economy, the new curriculum was revised to focus on learning outcomes and knowledge economy skills. As a result, new textbooks in mathematics were produced for all grades and supplemented with e-content.

Curriculum content is aligned with the standards of the U.S.-based National Council of Teachers of Mathematics. The main topic areas are Number, Algebra, Geometry, Measurement, and Probability and Statistics. Students must demonstrate competence in knowing, applying, and problem-solving cognitive domains. In addition, students are expected to master the following skills for the knowledge economy: communication; information management; problem solving in real-life situations; and using symbols, figures, and graphs. The expectations for students in the basic cycle, Grades 1–10, are described as follows: [7]

- *Number*—Demonstrate knowledge of place value and the four arithmetic operations (addition, subtraction, multiplication, and division); solve problems by computation, estimation, or approximation; and compare and order fractions and decimals.

- *Algebra*—Evaluate expressions for given numeric values of variables; simplify or compare algebraic expressions to determine equivalence; model situations using expressions; evaluate equations or formulas given values of 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 characteristics that make things measurable, as well as measurement systems and operations; and apply techniques, tools, and formulas to determine appropriate measurements.
- *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; use data from experiments to predict the chances of future outcomes; and formulate questions that require appropriate data collection.

Science Curriculum in Primary and Lower Secondary Grades

Jordan's three most recent major education reforms also have focused on enhancing the science curriculum. In 2003, Jordan started a 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. One year later, the curriculum was phased-in for all other grades.

For Grades 1–8, there is an integrated curriculum, while in Grades 9 and 10, science is taught as four separate subjects: biology, chemistry, physics, and Earth science. The expectations for students in Grades 1–8 are described as follows: [8]

- *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, facts, and various scientific measurements; follow safety rules and procedures in the classroom, 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 matter and energy; recognize the work of God in the universe and understand that the universe's materials have significant impacts on our lives; investigate by using the scientific method; use laboratory materials and tools to explore science principles; and follow safety rules and procedures in the laboratory, classroom, school, and home.

- *Organisms and their Environments*—Show an understanding of the characteristics of living organisms and their needs, life cycles, and relationships with each other and their environments; and demonstrate knowledge and skills necessary to understand the nature of the human body and to maintain one's health.
- *Meteorology*—Understand the components and characteristics of the atmosphere and its interaction with the Earth's surface.
- *Terrestrial Materials*—Understand the components and characteristics of land and water systems, their interactions, and human impact on them.
- *Astronomy*—Understand the components of the universe, its characteristics and origin, and the physical laws governing it.
- *Earth's History*—Describe Earth's changes over time.
- *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 interactions occur among natural systems, minerals, and weather.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

For Grades 1–10, mathematics constitutes 15 percent of total instructional time. Students study mathematics five periods per week, with each period lasting 45 minutes. In each grade, 10 to 19 percent of total instructional time is allocated to science. Students receive science instruction three to five periods per week in Grades 1–8, and seven periods per week in Grades 9 and 10. Also, in Grades 9 and 10, physics, chemistry, and biology are allocated two periods per week, and Earth science is allocated one period per week.

Instructional Materials, Equipment, and Laboratories

The ministry provides regularly updated lists of equipment and laboratory tools required by the school curriculum. Some tools and pieces of equipment are purchased from external suppliers while others are produced locally. The materials and equipment are distributed to schools, and the ministry receives feedback with respect to modifying and updating school laboratories. Because the ministry emphasizes decentralization, schools allocate a portion of their budgets to purchasing some materials and equipment.

For all students in Grades 7–12, schools have quality materials and equipment to support instruction. 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 up-to-date and that equipment and tools are in good condition.

Use of Technology

In a knowledge economy, the ability to use information and communication technology (ICT) is essential. In Jordanian education, ICT has become one of the most important tools for acquiring information, communicating with others, and developing new ideas.

Many schools in Jordan have high-speed Internet access, 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). Examples of using technology as a learning tool in Jordanian schools include the following:

- Using online material available 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; and
- Searching for references on a CD-ROM encyclopedia.

In addition, many professional development programs for teachers, supervisors, and senior administrators focus on using technology, such as the International Computer Driving License, Intel's Teach to the Future, and WordLinks. The Intel and WordLinks programs train and encourage teachers to employ project-based learning.

To support the needs of a variety of learning styles, the ministry has developed Knowledge Centers, or innovative school libraries, to enhance the student-centered approach to learning. The ministry has provided financial support to create these centers within schools, which offer a pleasant and welcoming environment for both students and teachers. Specifically, these centers have seating and study spaces for students as well as open access shelving for books, newspapers, magazines, audio and video tapes, CDs, DVDs, and computer software.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

Starting from fourth grade, students are taught by specialist teachers in mathematics and science. At minimum, teachers should hold a bachelor's degree to instruct any subject which includes mathematics or science.

Homework Policies

Teachers usually give students homework at the end of each lesson, especially in mathematics and science courses. They usually start the next lesson by checking the assignment and giving students feedback. Some teachers score homework assignments and include homework as a component of student assessment. Teacher guides explicitly include homework assignments. In mathematics and science, homework assignments often take the form of problem sets, written reports, projects, or research on an assigned subject for discussion during the next lesson.

Teachers and Teacher Education

Teacher Education Specific to Mathematics and Science

The Ministry of Education in Jordan recognizes that improving the quality of education is a priority for the nation's development and therefore an ultimate goal to be achieved. Important tools in achieving this goal include developing the quality of teacher education through progressive reform of education policies and strategies, and improving teacher training.

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, an urgent need of the Jordanian education system is to have highly qualified, competent teachers. The ministry has responded to this requirement by implementing the Education Reform for the Knowledge Economy (ERfKE) in two phases: ERfKE I in 2003–2009, and ERfKE II in 2010–2015. Key components in this reform are improved professional development and education, and improved learning resources.

The minimum requirement to be a teacher in Jordan is completing a bachelor's degree. Some of the specific requirements to teach mathematics and science include the following:

- Completion of a specific pre-service program for mathematics and science teachers;
- Teacher professional development, which is now a component considered during teacher certification; and
- Closer coordination with schools of education, to satisfy the requirements of the Ministry of Education for preparing competent mathematics and science teachers.

The efforts of the Ministry of Education Directorate of Training, Qualification, and Supervision concentrate on providing information to foster areas of strength and minimize areas of weakness in teachers. The directorate's ultimate goal is to help Jordanian students become innovative thinkers who can build their local community and participate in the development of the international community.

Requirements for Ongoing Professional Development

Through the implementation of the Education Reform for the Knowledge Economy project, teacher competencies are being developed, and a comprehensive teacher professional development plan is being prepared.

Monitoring Student Progress in Mathematics and Science

Assessment policies have been updated to ensure that classroom assessment practices conform with the Education Reform for the Knowledge Economy project, which places the student at the center of the learning process and focuses on each student's development as a responsible person and citizen within the knowledge economy. A set of assessment strategies and tools have been developed to monitor individual student progress, including performance-based assessment, observation, communication, reflection, checklists, rubrics, and learning logs. These are used to inform and generate grades, which are recorded along with grades collected from paper-and-pencil tests. New report cards have been designed to facilitate the new reporting system that focuses on basic skills and general learning competencies. Parents also receive supplemental information regarding their child's learning progress that may help them for future planning.[10]

According to regulations issued by the Directorate of Examinations and Tests, students in Grades 1–3 are promoted automatically unless a student earns 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, he or she must pass a make-up examination with a score of at least 50 percent. However, students are promoted even upon failing the make-up examination after two retentions during basic education (Grades 1–10). Acceleration of students is possible after careful assessment, special tests, and interviews to ensure student capability. However, acceleration may not exceed two grades. In secondary education, promotion and retention is course-based, and students may take any individual test more than once to fulfill the requirements of the General Secondary Certificate Examinations.[11] The General Secondary Certificate Examinations are examinations for those who have finished twelve years of schooling. There are different versions—academic and vocational—which correspond to the stream completed in secondary education. High stakes are attached to these examinations because the results are used for higher education admission purposes.

Impact and Use of TIMSS

Jordan has participated in all TIMSS cycles since 1999, with the principal goals of evaluating the curriculum with reference to international benchmarks and assessing the capabilities of Jordanian students compared to their international peers.

As a direct result of participation in the TIMSS assessments, committees were formed to revise the mathematics and science curricula. Also, released TIMSS items from previous cycles (1995, 1999, 2003, and 2007) have been used in the development of new textbooks for mathematics and science.

One of the major impacts of TIMSS in Jordan has been the development of teacher guides. Student responses from TIMSS 1999, 2003, and 2007 were studied thoroughly and used to prepare teacher guides in mathematics and science. These teacher guides are currently being used in teacher education programs and appear to have had a positive effect on student achievement in science. These teacher guides include the following topics:

- Identification of student errors on the assessment, their types, and how the errors occurred;

- Suggested questions and tasks that may help students become aware of how errors occur; and
- Suggested learning strategies, such as remedial tasks, which might help students deal with errors.

TIMSS has played a vital role in the development of the Education Reform for the Knowledge Economy project. The results of TIMSS 2003 were used as a baseline for the project, and TIMSS 2007 provided a new set of data that helped measure change in student achievement. TIMSS will continue providing valid and reliable data for monitoring and evaluating reform projects across time. Lastly, the results of TIMSS have elicited a great deal of interest in Jordan from educators, policy-makers, and the media because Jordan was one of the countries in which students achieved the international average in science but below the international average in mathematics. TIMSS results also have prompted the National Center for Human Resources Development (NCHRD) to produce a series of reports related to TIMSS, including the following: [12]

- *Performance Levels of Jordanian Eighth-grade Students in Math and Science with Respect to the Availability of Educational Resources: A Comparative Study*;
- *Mathematics Teachers' Guide Manual*;
- *Science Teachers' Guide Manual*;
- *Analysis of Students' Errors in the Context of TIMSS 1999: The Case of Jordan*;
- *An Analysis of the Obstacles to Science Teaching that Affected Jordanian Students' Performance in TIMSS 1999*;
- *Comparison of Jordanian Educational Policies with High Achieving Countries: Singapore, Taiwan and Japan*; and
- *Personal and Family Factors Discriminating Between High- and Low-achieving Eighth-grade Jordanian Students in TIMSS 1999.*

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Kazakhstan

National Centre for Education Quality Assessment (NCEQA)

Introduction

Overview of the Education System

According to the Constitution of the Republic of Kazakhstan, the state guarantees a free and comprehensive secondary education (Grades 1–11) for its citizens, and the 2007 Law on Education emphasizes that a high-quality education should be equally available to all.[1, 2] Education reform in the country is ongoing; currently, the national government is developing and implementing a policy of educational progress, including strategic plans for expanding the education system to include twelve years of primary and secondary education.

The Ministry of Education and Science is responsible for implementing education policy and allocating financial resources for education. The ministry has taken steps to implement national educational improvement programs, increase coordination among education sectors, develop international education programs, broaden networks connecting educational institutions, and improve government resource allocation policies.[3] Educational institutions are financed according to their legal status—public or private. Public educational institutions are financed by both national and local budgets, although most funding (61%, on average) comes from the local budget. Almost all primary and secondary schools are public.

In 2010, the Republic of Kazakhstan had 7,833 educational institutions in operation, of which 7,640 were public schools providing general education. There are a few general education day schools with a specific education focus as well as education complexes combining different education levels at one location (e.g., kindergarten together with primary grades, or lower secondary and upper secondary grades together with higher and professional education). Six President Schools offer international curricula, such as the International Baccalaureate, to students with high intellectual capabilities.[4] Especially gifted students can enroll in special programs which include in-depth studies of various academic subjects. These programs are implemented at educational organizations for gifted children, high schools, and *lycees*.[5]

Preprimary education includes nursery education and preschool education. This level is provided for children ages 1–6, but only is compulsory for ages 5–6. Preprimary education is provided by preprimary schools, which may be independent or incorporated into secondary schools.

Secondary education includes three levels: primary education, basic secondary education, and general secondary education. Primary education and basic secondary education together comprise what is known as general education.

- Primary education (Grades 1–4)—This level is provided in primary schools, in lower-secondary schools that include the primary level, or in secondary schools that include all three levels of education. The goals of primary education are the following: form a child's personality; develop his or her individual abilities; instill a positive attitude toward education; develop strong literacy, numeracy, and language skills; encourage self-realization; and teach behaviors that will help him or her master subsequent education programs in basic secondary school.
- Basic secondary education (Grades 5–9)—This level focuses on helping students master the foundations of science systems and develop interpersonal and interethnic communication skills, form a personal identity, and acquire vocational guidance.
- General secondary education (Grades 10–11)—This level focuses on subject content and vocational orientation. Programs are developed on the basis of differentiated instruction, integration, and vocational guidance; these programs also include specialized education in mathematics, natural science, and the humanities.

In accordance with the Law on Education, primary and secondary education is regulated mainly by the State General Standards of Education and the Ministry of Education and Science's general education programs (Grades 1–9).[6] The standards define the minimal and obligatory education requirements for students and the requirements for student assessment. General education programs are oriented to provide both academic and social education, especially at the primary level. As students move into higher grades, the educational system first helps them choose a profession or a vocation and then provides further training in their field of choice. General secondary (Grades 10–11) and higher education programs are divided into standard education and vocational education at the general secondary, professional, and tertiary levels, depending on their content and intent. In addition, integrated educational training programs have been developed by educational organizations with Ministry of Education and Science approval. Such programs are interdisciplinary, inter-level, inter-university, or international.

The Republic of Kazakhstan considers high-level student achievement in mathematics and natural science a top national priority. To this end, the national government annually allocates substantial financial resources toward achieving this goal. Specifically, the government provides funding for material improvements in mathematics and science education, including classroom resources, such as textbooks, multimedia support, ICT resources, and teacher professional development in these subjects.

Languages of Instruction

The Republic of Kazakhstan's multi-ethnic population is made up of individuals representing over 120 nationalities. Kazaks comprise 69.5 percent of the population, Russians, 22.8 percent, and Uzbeks, Ukrainians, Uighurs, Tartars, Germans, and other nationalities together comprise 8.6 percent.[7]

The national language of Kazakhstan is Kazakh. However, both Russian and Kazakh are officially used by national government organizations and local government bodies. English is used in international contexts, including international commerce.

Language policy in education is implemented in accordance with the Constitution of the Republic of Kazakhstan and legislation concerning languages.[8] Parents may choose the language of instruction for their children. Kazakh children generally study in the Kazakh language, while children of different nationalities (e.g., Russians and Uzbeks) generally study in Russian.

Most schools provide instruction in Kazakh and Russian. However, 33 special schools provide instruction in three languages— Kazakh, Russian, and English—to 7,034 students. In these schools, mathematics, physics, computer science, chemistry, biology, and geography typically are taught in English, using English instructional materials.

Mathematics Curriculum in Primary and Lower Secondary Grades

The *State Mandatory Standards of Education* describe the purposes, tasks, and objectives of mathematics at the primary, basic secondary, and general secondary levels of education.[9] Mathematics objectives for students in primary (Grades 1–4) and basic secondary (Grades 5–9) education are summarized as follows:

- Grades 1–4—Understand the concept of natural numbers and their use; develop skills in oral and written calculation with natural numbers and zero; gain experience making arithmetic task decisions and solving arithmetic problems with natural numbers; gain experience in solving application and real-life problems; gain some experience with geometric activities related to geometric figures and measuring geometric shapes; and develop skills related to explaining individual thought processes in mathematics, such as verbal skills and the correct application of mathematics vocabulary and symbols.

- Grades 5–6—Understand the concept of numbers and the role of calculation in everyday life, understand the concept of descriptive statistics, develop practical computation skills, and learn to write number sentences.

- Grades 7–9—(Algebra) Develop computation skills; use formal algebra operations; relate elementary functions with their respective properties and graphs; use concepts associated with functions and graphs to describe functional relationships; use mathematical concepts and methods to model real processes and phenomena; develop logical thinking and communication skills to support opinions; carry out simple algorithms; and use different forms of mathematical languages (verbal, symbolic, and graphic); and (Geometry) understand and apply characteristics and properties of geometric figures, including two-dimensional shapes; and gain experience using analytic tools to make geometric measurements and solve numerical problems in geometry.

The content of mathematics is traditionally built around the following components: [10]

- Numbers and Computation—Natural numbers, ordinary and decimal fractions, percents and proportions, whole numbers, rational numbers, the concept of irrational numbers, real numbers, order of operations, exponents, finding roots, logarithms, sines, cosines, tangents, and approximations and estimations.

- Mathematical Expressions and Transformations—Variables, letter and number expressions, and identities and their use in the transformation of expressions; algebraic expressions (monomial terms, polynomial functions, and fractions), and arithmetic operations with integer and fractional algebraic expressions; and exponential, logarithmic, and trigonometric expressions.

- Equations and Inequalities—Proofs of identity and inequality expressions; equivalence in equations and inequalities; identifying domains of equations and inequalities; equations and inequalities with one and two unknowns and their geometric interpretations; rational inequalities; and systems of equations and inequalities, and general solution methods for equations and inequalities.
- Functions—Numerical and elementary functions, and their properties and graphs; derivatives and anti-derivatives; integrals; and arithmetic and geometric progressions.
- Geometric Figures and Measuring Geometric Variables—Geometric figures and their properties (points, segments, rays, straight lines, planes, subspaces, angles, polygons, circumference and circles, polyhedra, and solids of revolution); geometric relationships (transverse, intersection, tangency, parallelism, perpendicularity, equality, correspondence, and symmetry); geometric values (length of lines, value of angles, area, and volume); vectors and coordinates; and using analytical tools in geometry.
- Elements of Probability Theory and Statistics—Ways of presenting statistical data (tables, diagrams, and histograms), calculation of descriptive statistics (mode, median, average, range, and standard deviation), graphs of real processes, calculation of variance, systematic enumeration, permutation, combinations, and geometric models of probability.

Science Curriculum in Primary and Lower Secondary Grades

Science in Grades 1–4 is taught through an integrated course called Knowledge of the World, which includes the study of nature, humans, and society.[11] The content of this science course includes the following components: [12]

- Nature—Living and non-living things and their attributes; natural phenomena, their properties, conditions, and interrelations; and the animal and plant world, including common features, basic needs, reproduction, and habitats.
- Humans—The concept of humans as a part of the natural world; significant features that differentiate humans from animals; and man's role in the development of science, technology, the environment, and society.

- Society—The homeland, family, school, and understanding oneself and one's position in society.

The contents of each subject are studied continuously from the first through the fourth grades and become more complex from grade to grade.

In basic secondary (Grades 5–9) and general secondary (Grades 10–11) education, the natural sciences are divided into geography, biology, chemistry, and physics and astronomy.[13, 14, 15, 16] Geography is studied in Grades 5–11, biology in Grades 6–11, and chemistry in Grades 8–11. The subject of physics and astronomy is studied only in Grades 7–9 of basic secondary education.

- Geography—By the end of Grade 9, students should have knowledge about Earth as one planet in the solar system; Earth's size and form; the different continents; natural features of the Earth that reflect its structure, space, and differences; processes and phenomena on Earth; material and spiritual cultural values reflecting human experiences of learning and existence; the type, structure, and characteristics of territories; the modern world and concepts relating to sustainable development and diversity of life; and global, regional, and local problems of modern geography and environmental and conservation issues.

- Biology—Across grades, biology covers molecular, cellular, tissue, organism, population, biogenetical, and biosphere levels of life organization; the diversity of living organisms, their interaction, ontogenesis, phylogenies, and evolution; systemic groups of organisms; the human being as a biosocial person; fundamental biological theories (cellular, evolutionary, and chromosomal), and frontier concepts (e.g., ecology, and the origin of life). Specifically, in Grades 6–9, students study living organisms, the diversity of organisms, evolution, and flora and fauna in the environment; ecology and the biosphere; humans and their health; the biology of cells; fundamentals of genetics and natural selection, including heredity and human genetics; and evolution.

- Physics and Astronomy—This topic area focuses on physical methods of studying nature, mechanics, molecular physics and thermodynamics, electrodynamics, atomic and nuclear physics, and astrophysics. By the end of Grade 9, students should have knowledge of motion, the molecular structure of substances, thermal effects, direct current, the interactions of magnets, electromagnetic waves, the atomic nucleus, nuclear power, and the structure and composition of the solar system.

- Chemistry—This topic area covers different organizational levels of substances, including simple and complex substances, pure substances and mixtures; broad classes of organic and inorganic substances, natural and chemical polymers, and the theory of the chemical structure 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 conservation of mass; physical and chemical changes; chemical elements and formulas, including atomic and molecular masses; oxygen, hydrogen, water, and the air; the main classes of inorganic compounds, the periodic table of chemical elements, covalent and ionic bonding, electrolytic dissociation of acids, bases, and salts; physical and chemical properties of metals and nonmetals; and foundational concepts of organic compounds.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

Instructional Materials, Equipment, and Laboratories

Current education improvement efforts in Kazakhstan are focused on increasing the quality and availability of instructional materials and technologies used in modern schools and classrooms.

Every year, the Ministry of Education and Science publishes a list of approved and recommended textbooks. Teachers can choose alternative textbooks and supplemental materials based on their professional preferences, student characteristics and interests, and parent opinions. Electronic textbooks (e-books) recently have been developed for the Kazakh education system and introduced in many village schools.

Between 2005 and 2010, the number of specialized classrooms in general education schools increased as a result of implementing the State Program for the Development of Education in the Republic of Kazakhstan.[17] In 2010, 81.4 percent of schools had physics classrooms, 75.8 percent had mathematics classrooms, 73.6 percent had chemistry classrooms, 69.0 percent had biology classrooms, 62.1 percent had geography classrooms, 74.9 percent had Kazakh language classrooms, and 53.9 percent had foreign language classrooms.

Use of Technology

An important component of modern education is the development of information systems. To this end, provisions for computers and related software, interactive white boards, and Internet connections have been steadily increasing, and both national and local budgets supply resources to support the implementation of these technologies. The student-computer ratio has been improving annually; currently, the average is 16 students per computer. However, while Internet access has reached 98 percent of city schools and broadband access is available in 37.3 percent of all schools, only 97 of the 4,225 village schools have basic Internet access.

Since 2005, efforts to equip schools with interactive multimedia classrooms have increased. Currently, a total of 3,571 schools (1,721 through national funding and 1,850 through local funding) each have five interactive classrooms: two universal and three subject classrooms for physics, chemistry, and biology.

An online education system has been introduced in Kazakhstan in addition to an education portal (e-Learning Portal Kazakhstan), which provides access to software for online lessons.[18] The Ministry of Education and Science continues to develop the e-learning system with the dual goals of equalizing the quality of education in city and village schools, and training technologically capable citizens.

Grade at Which Specialist Teachers for Mathematics and Science are Introduced

In Kazakhstan's education system, students in primary school (Grades 1–4) are taught all subjects by general classroom teachers. Beginning with the first year of basic secondary education (Grade 5), mathematics and the natural sciences are taught by subject teachers.

Homework Policies

Although there are no rules regarding the assignment of homework, mathematics and science tasks are generally given after each lesson. Recommendations for these assignments are included in curriculum documents.

Teachers and Teacher Education

The quality of education is defined by the education and qualification of those who teach. As the Kazakhstan education system has evolved, the demand for highly qualified teachers has increased, especially at the upper secondary level. Teacher preparation programs typically consist of pedagogical studies, subject coursework, extra-curricular activities (e.g., teaching practice, physical education, and military training), and a final assessment. Currently, the Ministry of Education and Science is developing a policy that will include graduate or postgraduate study in teacher preparation.

There are several different ways to become a primary school teacher. Many teachers are educated at higher education institutions in a four-year bachelor's degree program that confers a Bachelor of Pedagogy and Methods of Primary Education degree. Two-year programs for secondary school graduates or four-year programs for lower secondary school graduates also are offered at teacher's colleges. Those who receive a qualification as a primary school teacher at a teachers college usually continue their education at the graduate level. Bachelor's degree programs for primary teachers include the following: theoretical studies (5,760 academic hours), including research work, practical work, laboratory, and coursework; professional practice (270–2,205 hours); a compulsory curricular component (3,645 hours); and an elective curricular component.

The *State Standards for Higher Education* are compulsory and provide each higher education institution with the curricular basis for teacher education courses and programs in primary level mathematics, geography, physics, chemistry, and biology.[19] However, each institution can determine the distribution of study time among the compulsory and optional courses at their discretion.

The primary level teacher education curriculum results in a Bachelor of Education and includes four sets of subjects: general, basic, major, and elective. Compulsory general subjects (13.5% of the curriculum) include the history of Kazakhstan, Kazakh (Russian) language, foreign language, computer studies, philosophy, ecology, and physical education. Compulsory basic subjects (25.5% of the curriculum) include courses in pedagogy and philosophy, principles of mathematics, modern Kazakh (Russian) language, children's literature, principles of natural science, modern teaching technologies, theory of teaching mathematics, and global awareness with technology in primary school. Compulsory major subjects (11% of the curriculum) include technology and the education of primary students, methodology of scientific pedagogic research, teaching art, theory and teaching technology in the visual and performing arts, labor, and computer studies in primary school. Elective subjects comprise the remaining portion (50%) of the curriculum. In addition to the compulsory and elective subjects, prospective teachers also must gain work experience and undergo teaching and practical training.To become a teacher of mathematics, geography, physics, biology, or chemistry at the basic or general secondary levels (Grades 5–11), it is necessary to earn a bachelor's degree in education and an additional bachelor's in the specialty subject to be taught.

Requirements for Ongoing Professional Development

Qualification improvement and retraining of educational personnel is compulsory for teachers by order of the Ministry of Education and Science. Every year, teachers improve their qualifications by attending university professional development courses that extend their professional knowledge, improve their teaching skills, and effectuate their creativity in the profession. In 2011, more than 61,000 teachers passed advanced training courses; in 2010, more than 80,000 did so.

There are several national competitions that highlight outstanding teachers—Best Teacher, Best Form Master, Best Teacher of Kazakh Language, and the *Altyn disc* contest for ICT teachers. City competitions (*Bilim Uyasy*) for Best Manager in Education and Best Educational Institution are conducted every five years.

Monitoring Student Progress in Mathematics and Science

Procedures to monitor curriculum implementation are in place in educational institutions. A new form of self-assessment has been proposed for schools, which would include the following components: individual student achievement (classroom examinations, end-of-year examinations, and independent study projects), school-wide achievement (thematic knowledge of subjects and general assessment of student academic progress), and administrative achievement (e.g., organization and quality of the educational process).

Students are assessed to compare achievement with curriculum requirements and to provide diagnostics of academic student progress. Assessment results inform school accreditation and teacher evaluation processes. Such assessments usually occur at the end of each school year in each subject, and include oral examinations and short response, extended response, and multiple choice written examinations. Schools typically use internal, teacher-generated tests or external tests developed at the regional or national level.

At the national level, Kazakh students are assessed by the Intermediate State Control (ISC) and Common National Testing (CNT) examinations. Each year, a sample of ninth grade students is assessed by ISC assessments, which provide feedback on both educational services and students' level of attainment of primary and general secondary education objectives. Mathematics and science subjects play a central role in ISC.

CNT combines end-of-year certification and higher education admission examinations for graduates of general education schools. Additionally, students in Grades 5–10 must pass "transfer" examinations in their subjects to be promoted to the next grade.

Impact and Use of TIMSS

In 2007, the Republic of Kazakhstan participated in TIMSS for the first time as part of policy stipulated in the State Program for the Development of Education (2005–2010).[20] In 2011, the mathematics standards in place since 2002 were updated to include an introduction to combinatorics and probability as well as elements of statistics. In-service teacher education also has increased, though advanced training is not offered in Intellectual Schools of the First President, where the best teachers learn to use up-to-date education technologies and develop their craft. Additional programs are offered at the National Center for Teachers' Professional Development.

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Republic of Korea

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Introduction

Overview of the Education System

Grounded in the ideal of *hongik-ingan* (universal welfare of mankind), the objectives of Korean education are to assist all people in perfecting their individual characters, developing the ability to achieve independent lives, and acquiring the qualifications of democratic citizens, which will allow them to participate in building a democratic state and promote the prosperity of all humankind.

Article 24 of the Act on Government Organization stipulates, "The Ministry of Education, Science, and Technology shall oversee and coordinate human resources development policies, and govern matters related to school education, lifelong education, and other academic affairs." [1] The Ministry of Education, Science, and Technology (MEST), therefore, is responsible for contributing to the establishment of a society, which promotes open and lifelong education, as well as the promotion of science and technology development.

With the enactment of the Local Autonomy Law[2] in 1991, new modes of operation promoted educational autonomy at the local level. Educational administration became decentralized, and MEST delegated much of its budget planning and major administrative decisions to local authorities. Thus, the metropolitan and provincial offices of education offer a set of operating guidelines for curriculum organization and implementation at the school level to community education authorities and schools within their jurisdictions. The national curriculum and 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: six years of elementary school, three years of both middle school and high school, and four years of university education. This is to ensure that all students receive an education without discrimination, according to their abilities.

The goal of preprimary education, for students ages 3–5, is to provide an appropriate environment for nurturing children and promoting their holistic development through various enjoyable activities with diversified content and methods of instruction.

Elementary education in Korea, Grades 1–6 (ages 6–11), is free and compulsory, and provides the general, basic education necessary for a productive life.[3]

Middle school includes Grades 7–9 (ages 12–14) and also is free. The purpose of middle schools, which have been compulsory since 2002, is to conduct standard secondary education on the foundations laid in elementary schools.

The Korean national curriculum is revised on a periodically to reflect newly arising demands of education, emerging needs of a changing society, and new frontiers of academic disciplines. Curriculum standards serve as the basis for educational content in each school and for textbook development. The government developed a revision of the national curriculum—the 2007 Revised National Curriculum—to meet evolving national and social needs. Another revision of the national curriculum is scheduled for all grades in 2011 in order to nurture creative student talent and to develop an environment of consideration and sharing.

Korea has established 23 special science high schools governed by the metropolitan and provincial offices of education as of 2011. These schools aim to develop human resources in advanced science and technology fields by selecting students who are gifted in science, encouraging them to develop their talents, and preparing them to become leaders in science and technology. The schools use the following curricular organizing principles:

- Subjects are classified into common and specialized subjects suitable for the students;
- Common subjects are organized with reference to the credit allotment for science courses in regular high schools, and specialized subjects are designed to challenge the brightest students; and
- Mathematics and science classes are allotted standard instructional time, and advanced courses are conducted according to the characteristics of each subject.

The Ministry of Education, Science & Technology recently recruited teacher's research councils for STEAM (Science, Technology, Engineering, Art, and Mathematics) education to introduce STEAM into primary and secondary education as of mid-2011. Teacher's research councils are comprised of STEAM subject teachers and are organized and operated in order to develop curricula and teaching materials pursuant to the STEAM education initiative. In addition, as of September 2011, the ministry began to administer the STEAM Education Leading Schools. The various programs related to science, technology, engineering, art, and mathematics education will be developed and distributed in 2012.

Languages of Instruction

The language of the Republic of Korea is Korean. Education is, therefore, offered in Korean. According to the most recent census in 2010, the country's population was 48.1 million.[4]

The Korean Curriculum in Primary and Lower Secondary Schools

The Korean National Curriculum consists of the national common basic curriculum and the high school elective-centered curriculum.[5] The national common basic curriculum is made up of subject matter content, optional activities, and extracurricular activities. The subject matter is divided into ten areas: Korean language, moral education, social studies, mathematics, science, practical arts (technology and home economics), physical education, music, fine arts, and foreign language (English). The subject matter for Grades 1 and 2 is, however, condensed into Korean language, mathematics, disciplined life, intelligent life, pleasant life, and "We are the first graders."

The basic emphasis of the seventh National Curriculum, which was applied to the eighth grade, is as follows. Mathematics in the national common basic curriculum is organized and implemented as a differentiated curriculum. Ten levels of mathematics courses are offered from Grades 1–10, and each level is divided into two sublevels that are taught on a semester schedule. Students must complete one level to move on to the next. Those who fail must take special supplementary classes. Each level has six content domains, which are taught at multiple levels of difficulty. The more able and qualified students take advanced-level classes and study the curriculum in greater depth. Those who have difficulty following the content of study may take supplementary classes. District offices of education or officials at schools may differentiate the curriculum.

Science is offered from Grades 3–10 and is also designed for in-depth and supplementary study. An in-depth course is available for those students who have completed all required subjects. Those who have shown poor achievement may take supplementary courses, but the curriculum offers nothing for these students.

Some changes brought about in the 2007 Revised National Curriculum have been applied to the fourth grade.[6] For example, optional activities were changed to discretionary activities. In elementary schools, creative discretionary activities are offered across all subjects based on the educational needs of schools and students' self-directed learning. Schools may selectively implement diverse discretionary activities, such as theme-based studies, collaborative team projects, studies on how to learn, or integrated cross-curricular subjects according to the needs of the schools, teachers, and students. Differentiation is not solely based on student achievement level, but can be made by the district offices of education or at the school level.

In addition, classes are offered 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 offices of education offer programs for gifted students in a variety of areas including mathematics and science. As of 2010, there were 907 institutions for gifted students with 3,283 students enrolled in mathematics programs and 3,404 students enrolled in science programs nationwide.[7]

Mathematics Curriculum in Primary and Lower Secondary Grades

The objectives of mathematics education are to:

- Obtain mathematical knowledge and develop mathematical skills;
- Cultivate the ability to think and communicate mathematically in order to investigate diverse phenomena and problems;
- Construct practical solutions; and
- Cultivate a positive attitude toward mathematics.

A deep understanding of the application of mathematical concepts, including practical problem-solving abilities, is essential to learning diverse subjects and also is necessary for developing professional skills and the ability to solve problems as a democratic citizen. Moreover, mathematical knowledge and reasoning methods act as an intellectual driving force in the development of human civilization, and are necessary in the rapidly changing future of information technologies.

The fourth grade students who took part in TIMSS 2011 studied under the 2007 Revised National Curriculum. In the mathematics curriculum of the elementary schools, the content comprised five domains: Numbers and Operations, Figures, Measurement, Probability and Statistics, and Patterns and Problem Solving. The topics and skills taught in each grade are described briefly below:

- Grade 1—(Numbers and Operations) numbers up to 100, addition and subtraction of simple numbers, and addition and subtraction of two-digit numbers; (Figures) shapes of solid and plane figures; (Measurement) comparisons of quantities and telling time; (Probability and Statistics) classification, categorization, and tallying of things; and (Patterns and Problem Solving) determining and expressing patterns, and solving problems.
- Grade 2—(Numbers and Operations) numbers up to 1,000, addition and subtraction of two-digit numbers, addition and subtraction of three-digit numbers, multiplication, and fractions; (Figures) basic plane and solid figures; (Measurement) measuring time and lengths (e.g., centimeters and meters), and expressing measured values; (Probability and Statistics) constructing charts, graphs, and tables; and (Patterns and Problem Solving) finding patterns, writing and solving expressions containing unknowns, and solving problems.
- Grade 3—(Numbers and Operations) numbers up to 10,000, addition and subtraction of four-digit numbers, multiplication and division, fractions in base ten, and decimals; (Figures) angles and plane figures, translating plane figures, and components of a circle; (Measurement) measuring time, lengths (e.g., millimeters and kilometers), volume, and weight; (Probability and Statistics) properties of data and data organization; and (Patterns and Problem Solving) finding patterns and solving problems.
- Grade 4—(Numbers and Operations) numbers above 10,000; natural numbers and the four fundamental arithmetic operations, addition and subtraction of fractions with a common denominator, and addition and subtraction of decimals; (Figures) angles and triangles, and polygons; (Measurement) measuring angles, perimeters of plane

figures, areas of rectangles and squares; and estimation; (Probability and Statistics) constructing and interpreting trend graphs; and (Patterns and Problem Solving) finding and constructing patterns, determining correspondence; and solving problems.

- Grade 5—(Numbers and Operations) divisors and multiples, reducing fractions and determining common denominators, relating decimals and fractions, addition and subtraction of fractions without common denominators, multiplication and division of fractions, and multiplication and division of decimals; (Figures) properties of rectangular parallelepipeds and cubes, congruence, and symmetry; (Measurement) areas of plane figures; (Probability and Statistics) stem-and-leaf diagrams, pictographs, and data interpretation; and (Patterns and Problem Solving) ratios and rates; and solving problems.
- Grade 6—(Numbers and Operations) division of fractions, division of decimals, and mixed calculations of fractions and decimals; (Figures) properties of prisms, pyramids, cylinders, cones, and other solid figures; (Measurement) ratio of the circumference of a circle to its diameter, π (pi), and its area; and the surface areas and volumes of spheres and cylinders; (Probability and Statistics) constructing and interpreting graphs, and outcomes and probability; and (Patterns and Problem Solving) algebraic equations, proportional expressions, ratios and proportional relationships, and solving problems.

The eighth grade students who took part in TIMSS 2011 also studied under the seventh National Curriculum. In the mathematics curriculum of the middle schools, content also comprised five strands: Numbers and Operations, Variables and Expressions, Patterns and Functions, Probability and Statistics, and Geometry. The topics and skills taught in seventh and eighth grades are described briefly below:

- Grade 7—(Numbers and Operations) sets, prime factorization, greatest common divisors, least common multiples, decimal and binary systems, integers, rational numbers; (Geometry) points lines, planes, angles; relationships among points, straight lines and planes; properties of parallel lines; simple constructions with a ruler and compass; properties of and conditions of congruence in triangles; relationships between central angles and arcs in circles; properties of polyhedra and solids of revolution; properties of polygons; interior and exterior angles, area of a sector and length of an arc, and surface areas and volumes of solid figures; (Probability and Statistics) frequency tables, histograms, mean of data in the frequency table, and distribution of relative and cumulative frequencies; (Variables and Expressions) variables, evaluating expressions, addition and subtraction of linear expressions; linear equations and properties of equalities; and (Patterns and Functions) direct and inverse proportions; functions, ordered pairs, coordinates, and graphs; and applications of functions.

- Grade 8—(Numbers and Operations) recurring decimals, and the relationship between rational numbers and recurring decimals; (Geometry) proofs of the properties of triangles, rectangles, and parallel lines; properties of similar figures; approximation of values and errors, and the range of true values; (Probability and Statistics) basic properties of probability, calculation of simple probabilities; (Variables and Expressions) addition and subtraction of quadratic expressions, laws of exponents, division of polynomials, linear equations with two unknowns, simultaneous linear equations, solutions and basic properties of inequalities, linear inequalities, and simultaneous linear inequalities; and (Patterns and Functions) graphs of linear functions, solution of simultaneous linear equations by graphing, and applications of linear functions.

Science Curriculum in Primary and Lower Secondary Grades

Through the science curriculum, students develop the scientific literacy necessary to creatively and scientifically solve the problems of daily life. Specifically, the science curriculum aims to accomplish the following:

- Help students understand the basic concepts of science through inquiry;
- Encourage an interest and curiosity in natural phenomena and objects; and
- Develop scientific thinking skills as well as creative problem solving abilities.

Science in the national common basic curriculum is designed for all students in Grades 3–10. In science, learning is centered on various inquiry-based activities depending on student abilities. Activities include observing, experimenting, investigating, and discussing. Learning emphasizes group as well as independent activities in order to nurture scientific attitudes and communication skills, including criticism, openness, integrity, objectivity, and cooperation. Learning also stresses the comprehensive understanding of basic concepts (rather than a fragmented acquisition of knowledge) and the ability to solve problems scientifically in daily life using that knowledge.

The fourth grade students who took TIMSS 2011 studied under the 2007 Revised National Curriculum. The content of the science curriculum included the domains of Motion and Energy, Material, Life, and Earth and Space, and had links to basic concepts and inquiry processes across grades and domains. In addition, it consisted of free inquiry, providing students the opportunity to select topics based on their own interests, in order to enhance interest in science and develop creativity.

- Grade 3—(Motion and Energy) properties of magnets, and light traveling in a straight line; (Material) properties of objects and materials, liquid and gases, and the separation of mixtures; (Life) life cycles of animals, and the animal world; and (Earth and Space) weather and its effects on our lives.
- Grade 4—(Motion and Energy) weight and heat transfer; (Material) phase changes of water; (Life) life cycles of plants and the plant world; and (Earth and Space) geological strata and fossils, volcanoes and earthquakes, and changes in Earth's surface.
- Grade 5—(Motion and Energy) velocity and electric circuits; (Material) processes and properties of solutions; (Life) plant structures and functions, the world of micro-organisms; and the human body; and (Earth and Space) the Earth and moon system, the solar system, and the stars.
- Grade 6—(Motion and Energy) light, energy, and magnetic fields; (Material) acids and bases, gases, and processes and properties of combustion; (Life) ecosystems and environments; and (Earth and Space) weather and seasonal changes.

The eighth grade students who took TIMSS 2011 also studied under the seventh National Curriculum. The science curriculum included concepts associated with Energy, Material, Life, and the Earth. In addition, the curriculum encouraged the development of basic scientific knowledge, inquiry skills, and the promotion of scientific literacy.

- Grade 7—(Energy) reflection, refraction, composition, and resolution of light; forces; and the properties of waves and sound; (Material) the three phases of matter, the motions of molecules, and the relation between phase change and energy; (Life) cells and the organization of an organism; and digestion, circulation, respiration, and excretion processes; and (Earth) the structure of the Earth, materials of the crust, and the components and movements of water in oceans.

- Grade 8—(Energy) the motion of objects, and electrical current and voltage; (Material) the properties of matter, and the classification of mixtures; (Life) the structure and function of plants, and reactions to stimuli; and (Earth) the Earth, the stars, the history of the Earth, and movements of the Earth's crust.

Instruction for Mathematics and Science in Primary and Lower Secondary Grades

In principle, an instructional hour is 40 minutes for elementary schools, 45 minutes for middle schools, and 50 minutes for high schools. The minimum yearly instructional hours for mathematics and science by grade during the 34 weeks of the school year are as follows:

- Mathematics—In Grade 1, 120 hours; and in Grades 2–8, 136 hours per grade; and
- Science—In Grades 3–7, 102 hours per grade; and in Grade 8, 136 hours (Intelligent Life is a combination of social studies and science in Grades 1–2).

Instructional Materials, Equipment, and Laboratories

Textbooks and teachers' manuals are developed within the framework of the national curriculum. Textbooks compiled within the framework of the curriculum are classified into three types: government-copyrighted textbooks, government-authorized textbooks, and government-approved textbooks. Government-copyrighted textbooks are textbooks whose authorship belongs to the national government. Government-authorized textbooks are textbooks that private publishers have developed which have been authorized by the national government. Government-approved textbooks are textbooks that have received approval, but whose standards are lower than those of the authorization review board. Elementary schools use government-copyrighted textbooks, and middle schools use government-authorized textbooks.

In mathematics, students in Grades 1–6 receive specially developed or recommended instructional activity materials separate from the textbook. In science, students in Grades 3–6 use science textbooks and experimental observation materials to support inquiry activities.

In mathematics, calculator use is recommended not only to perform complicated calculations but also to help students understand mathematical concepts, principles or laws, and to solve mathematical problems. Calculators, however, are not to be used for teaching, learning, and developing calculation skills. In the science curriculum, the appropriate use of computer communications networks and multimedia is clearly stated as an objective. Moreover, information and communication technology is required for 10–20 percent of in-class practice.

In addition to standard instruction, many students have taken advantage of private education by attending "after-school classes" in school. As an example, OECD PISA has reported that one of the factors accounting for higher academic achievement in the Republic of Korea is that most students attend private, after-school classes.[8]

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. In addition, in secondary schools, the subject classroom system (the organization of schooling where students change classrooms between periods rather than a level-based system) is expanding gradually in order to support increased specialization in subject matter content.

Teachers and Teacher Education

Teacher Education Specific to Mathematics and Science

The classification and qualifications of teachers are defined in Section 2, Article 21 of the Act on Elementary and Secondary School Education. Teachers are classified into Teacher Grade I and Grade II, and are required by Presidential Decree to meet the specific qualification criteria for each category and to be licensed by the Minister of Education, Science, and Technology and the Department of Education, Science, and Technology.

Universities of education, colleges of education, departments of education, and those general colleges and universities with teacher certification programs provide teacher education for pre-service teachers. Four-year, national education universities prepare most primary school teachers. Secondary school teachers are prepared for four years in the universities' colleges of education, in the departments of education in general colleges, at the National University of Education, and at graduate schools of education. Being a teacher in Korea requires a degree from a teacher education program and a practicum during such a program.[9]

After completing a teacher education program for pre-service teachers, an individual is qualified for Teacher Grade II. To teach in public schools, the individual must pass the annual Teacher Qualifying Examination, which consists of three stages. For primary school teachers, the first stage is a written test about the curriculum and pedagogy. The second stage requires an essay demonstrating pedagogical knowledge, and the third stage consists of an in-depth interview. The secondary teacher qualifying examination also consists of three stages: a written test on content and pedagogical knowledge, an essay on content and pedagogical knowledge, and an in-depth interview, including creating lesson plans. Teacher-qualifying examinations are very competitive, and teachers who pass the examination are judged to have good content and pedagogical knowledge and teaching skills.

Teachers' salaries are composed of a gross salary based on a salary step system and additional bonuses to that base salary. To promote the welfare of teachers and to provide financial security, so that those in the teaching profession can devote themselves fully to their profession, the Korean Teachers' Mutual Fund and the Korean Teachers' Pension have been established.

Requirements for Ongoing Professional Development

In order to improve the quality and professionalism of teachers, Korea provides training programs through education offices and universities. Teachers with more than three years of service must participate in a 180-hour professional development program for qualification for Teacher Grade I during their summer or winter vacations to improve their teaching ability. Recently, distance-learning programs for teachers have been expanding. Teacher education programs offer programs to develop higher qualifications or performance training to strengthen capacities, and are provided at educational centers under the jurisdiction of city and provincial education offices, university-affiliated education centers, and private education centers. The methods for delivering these programs include in-class sessions, distance learning, and learning at home.

Monitoring Student Progress in Mathematics and Science

To ensure quality control over the national curriculum, the National Assessment of Education Achievement (NAEA), a student scholastic achievement test, is conducted annually at the national level. The goal is to assess educational progress and achievement; monitor the quality of education at the 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. Prior to 2008, the NAEA was given to a sample of 3–5 percent of elementary sixth grade students, third year middle school students, and first year high school students, in the subjects of Korean, social studies, mathematics, science, and English. Since 2008, the assessment has been extended to evaluate the sixth grade of elementary school, the ninth grade of middle school, and the eleventh grade of high school. The results of this assessment are documented in a national report, providing information at the student level. In addition, since 2010, NAEA has made the results available to the public through a website (http://www.schoolinfo.go.kr). Student level results do not influence student grades received in school; however, schools provide appropriate support for students based on the student performance results. Based on the results of NAEA, underachieving schools have been supported by the Korean government. This has resulted in a dramatic decrease in the number of below-basic level students since the administration of NAEA in 2008. In order to be admitted to a university, students must take the College Scholastic Ability Test (CSAT) after completing Grade 12. The CSAT attempts to increase colleges' and universities' ability to select persons most suitably qualified for higher education, and provide fair and objective student data to assist in admissions selections. The CSAT is very important for students' futures, since most of the colleges and universities in Korea use the CSAT scores as a basic indicator when selecting or screening for the best students. Because most high-level universities use CSAT scores, students who want to be admitted to these schools need high CSAT scores. Attending these highly respected universities will give students superior career opportunities.

The metropolitan and provincial offices of education also have operated some entrance tests for high school admission, and administered the diagnostic assessment for students independently from the ministry.

Schools conduct evaluations of student achievement levels by grade and level of subject area, using various assessment tools and methods. In principle, elementary schools provide evaluation records in the form of written documents for individual students. These report on the student's activities, personal characteristics, and academic progress.

Middle school students are evaluated at the end of each semester, with results recorded on individual school transcripts by each subject teacher. Results include the student's rank, as well as the total number of students enrolled in the subject course. The number of students of the same rank is also indicated.

A student's level of academic performance on tests is evaluated and the student is given a letter grade according to the percentage group into which she or he falls: 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 is also included in the transcript.

Impact and Use of TIMSS

Korea has participated in TIMSS four times since 1999. Although the impact of TIMSS results has been moderate for educational policies and reforms, researchers as well as policy makers have continuously tried to benchmark and reference TIMSS results and analyses for educational policymaking at the national level.

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Kuwait

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Ministry of Education

Introduction

Overview of the Education System

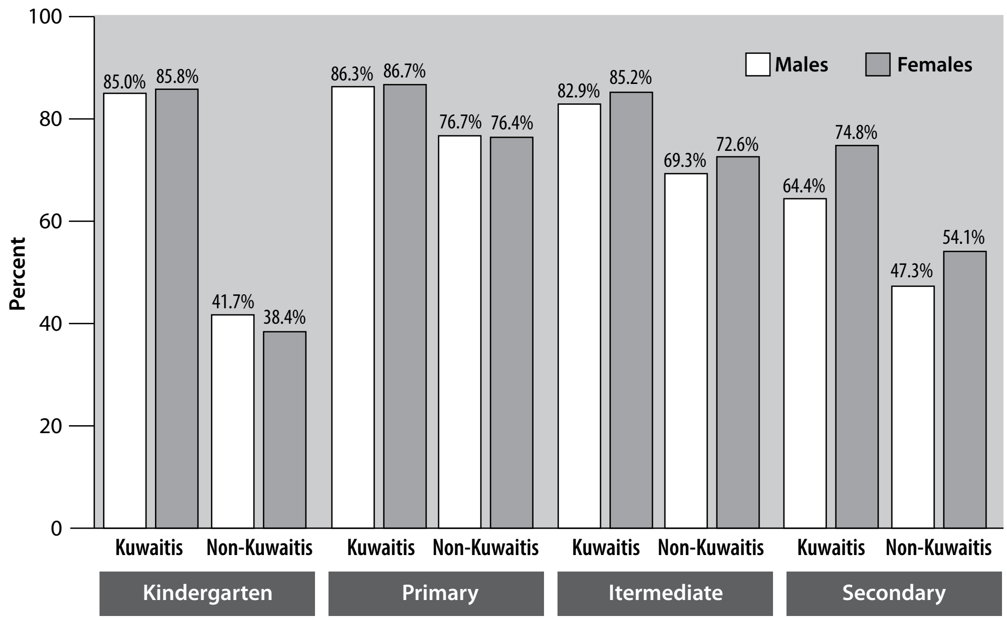
In Kuwait, the Ministry of Education is responsible for administering the public school system, including enforcing general rules and regulations, developing curriculum and pedagogical methods, and recruiting national and non-national teachers. While the education system is centralized, six district-level offices have responsibility for teacher assignment, assessments that contribute to the final secondary school public examination grade, 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 Kuwait, school is compulsory for children ages 6–17. Kuwait's education system consists of five years of primary education (ages 6–10, Grades 1–5), four years of intermediate education (ages 11–14, Grades 6–9), and three years of secondary education (ages 15–17, Grades 10–12).[1] Recent education reforms include the replacement of a two-tiered secondary system with a unified system. The government also supports two 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 is not compulsory and only fulfills a social function.

Exhibit 1 presents the net enrollment ratio for each of the kindergarten, primary, intermediate, and secondary levels. The data reveal that, Kuwaitis have much higher participation rates than non-Kuwaitis at all education levels, but most noticeably at the kindergarten level.

Public education is provided free for Kuwaiti and some non-Kuwaiti children (e.g., children of teachers or professors, Kuwaiti mothers, or Gulf State nationals). While overall expenditure per student is similar to the Organization for Economic Co-operation and Development (OECD) average, a closer analysis shows an imbalance in per student expenditure in favor of tertiary and vocational students as well as kindergarten students as compared to primary, intermediate, and secondary education students. Students attending private schools (e.g., 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 operational costs and textbooks.

Exhibit 1: Net Enrollment Rate in Public and Private Schools by Nationality, Level, and Gender[2]



In the 2010–11 school year, there were 1,406 schools in Kuwait, including the following: 788 public, 489 private, 29 schools for special needs students, and eleven religious schools. A limited number of religious schools cater to males from the intermediate school level through the secondary stage. Kuwait also has 89 adult education centers.

In the 2010–11 academic year 597,444 students were enrolled in Kuwaiti schools. This number encompasses both public education (general education, adult education, special needs education, and religious education) and private education. Exhibit 2 shows the distribution of students in Kuwaiti schools during that year.

In private schools, Kuwaiti students accounted for approximately 36 percent of kindergarten enrollment, 23 percent of primary school, 20 percent of intermediate, and 26 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 reflects the fact that the children of many non-Kuwaitis reside in their home countries.

Exhibit 2: Number of Students Enrolled in Kuwaiti Schools, 2010-11

	Kuwaiti	Non-Kuwaiti
Public Schools	311,216	42,111
Private Schools	58,055	154,563
Special Education Schools	1,364	382
Religious Schools	2,408	590
Adult Education Centers	18,558	8,197

Students attending Kuwait public schools and private Arabic schools follow a common national curriculum. Students in foreign private schools have curricula and courses similar to those offered in the affiliated countries, although these schools also are required to include aspects of the Kuwaiti culture and language in their curriculum. At the primary, intermediate, and secondary education stages, tracking or streaming within schools is not permitted.

The Ministry of Education provides general support for mathematics and science. At the secondary level, the Kuwait Foundation for the Advancement of Sciences provides additional support for specific activities related to mathematics and science, 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 also fosters interest in science through its support of science clubs.

Languages of Instruction

In Kuwait, 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, often is 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.

In 2008, Kuwait had a population of approximately 3.3 million, of which two thirds were non-Kuwaitis, mainly from Bangladesh, Egypt, India, Pakistan, the Philippines, and Sri Lanka.[3] The vast majority of the country's population resides around Kuwait City. In 2010–11, the school-age population (ages 4–21) included approximately 537,566 Kuwaiti and approximately 477,352 non-Kuwaiti students.

Mathematics Curriculum in Primary and Lower Secondary Grades

The general directors of mathematics and science education in each educational district consult with the curriculum department of the Ministry of Education to make curricular decisions. Recently, the mathematics curriculum has been under revision, and Kuwait began implementing the revised mathematics curriculum gradually, beginning with Grades 1–3 in the 2008–09 academic year, Grades 4–5 in 2009–10, Grades 6–7 in 2010–11, and Grades 8–9 in 2011–12. 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:

- Numbers and Operations—Recognizing and counting numbers up to 9,999,999; place value; comparison and order; simple operations in addition, subtraction, multiplication, and division; simple fractions; decimal fractions; and problem solving.
- Algebra—Properties of addition and subtraction; rule identifying patterns and solving equations; and solving open sentences.
- Measurement—Measuring weights, lengths, area, and temperature capacity; calculating circumference, area, and volume; and reading and writing time.
- Geometry—Discriminating shapes; types of triangles; intersecting, parallel, and perpendicular lines; and symmetry.
- Statistics—Reading graphical representations; and becoming familiar with range, median, mode, and mean.

By the end of Grade 8, students should have covered the following: rational numbers; ratio and proportion; factors and multiples; fractions; decimals and percentages; algebraic expressions; mathematical sentences; basics of statistics and probabilities; transformation geometry, including reflection, translation, and rotation; geometry of quadrilaterals, parallelograms, triangles, and circles; congruency; measurement related to length; volume and area; problem solving or application of these curricular topics; and principles of statistics and probability.

Science Curriculum in Primary and Lower Secondary Grades

Recently, the science curriculum also has been under revision. As with mathematics, Kuwait began implementing the revised science curriculum gradually, beginning with Grades 1–3 in the 2008–09 academic year, Grades 4–5 in 2009–10, Grades 6–7 in 2010–11, and Grades 8–9 in 2011–12. The new curricula contain the same basic concepts that existed in previous curricula, including international, structural, and cumulative concepts, but topics are presented in a new way, with deeper explorations of scientific material.

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—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—Light, sound, temperature, fire, magnetism, water, air, pollution, electricity, and transportation.
- Earth and Space Sciences—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. At this level, the curriculum is divided into three sections: life sciences, natural sciences, and Earth sciences and astronomy.

- Life Sciences—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 structure and cells, and HIV-AIDS, including protection against the disease.
- Natural Sciences—Elements and compounds, mixtures and solutions, features of materials, temperature, power and energy, magnetism, sound, acids, bases, salts, the atom, electricity, light, mass, and measurement.
- Earth Science and Astronomy—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

By international standards, the academic year in Kuwait is short and the number of instructional hours is low. The academic year is 33 weeks of the primary level and 32 weeks at the intermediate and secondary levels. While there has been an increase in the number of hours per year that primary students were 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 OECD average. During intermediate and secondary school, students are expected to receive 800 hours of instruction annually.

In Grades 1–5, mathematics instruction is five periods per week, with each period lasting 40 minutes. In Grades 6–9, there are five 45-minute periods of mathematics per week. The number of mathematics periods for students in Grades 10–12 (sciences branch) is six per week, each also lasting 45 minutes. Students in the arts branch of Grade 11 and Grade 12 have two 45-minute mathematics periods per week.

In the primary and intermediate education levels, science instruction is not differentiated by subject. In Grades 1–5, science is taught in three 40-minute periods per week, and increases to four 45-minute periods per week in Grades 6–9. At the secondary level, science instruction is differentiated: in Grades 10–12, physics and chemistry are taught together in three periods per week; in Grade 11, geology is taught twice per week; in Grades 10 and 11, biology is taught twice per week, and in Grade 12, three periods per week.[a] At the secondary level (Grades 10–12), class periods last 45 minutes in Grades 10–12.

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, and calculators. Schools also have science laboratories.

Use of Technology

A variety of technology is used in instruction and for distance learning, including computers and calculators. Technical supervisors and schoolteachers can use available programs for teaching mathematics and science lessons. Some integrated lessons introduced by computer teachers aim at training students to use computers, and students are assigned some activities using computers.

a The actual number of class periods offered over the school year tends to be considerably lower because of holidays.

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.

Homework Policies

In the enhanced mathematics curriculum, homework and class work are given as follows:

- Students have a mathematics lesson every day, during which they are assigned some exercises and worksheets to be answered in cooperation with the teacher or with peers. The last part of every lesson is dedicated to exercises and questions about the lesson. When students cannot complete these exercises during the class period, they are instructed to complete them at home.
- Outstanding students have an exercise book, which includes main exercises and enrichment exercises; teachers assign remedial exercises for low-achieving students.
- Teachers assign homework three times a week at least, or as needed.
- There are official instructions not to assign homework during public holidays.

There is no specific policy in the ministry regarding the amount of science homework teachers should assign. The amount of homework depends on the directions of technical supervisors. At the primary level, science homework often is assigned once a week, and on other days, students complete exercises with the help of the classroom teacher. In the enhanced science curriculum, homework is given in the following ways:

- Exercises in the classroom, where students answer some questions at the end of the lesson, and the teacher reviews the answers with the class.
- Homework outside the classroom, where students are given some questions at the end of every two or three lessons, to be answered at home, and the teacher corrects them later.
- Homework at the end of the unit, to be answered by students with the help of their parents.

Teachers and Teacher Education

A teacher must have a university degree to be formally recognized. Four-year teacher education programs are offered by the following: the Department of Education at 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. Students enrolled in all majors within each college are expected to take common courses in education and psychology, and specific teaching methods courses cover the topic of teaching mathematics and science. In addition, teacher preparation includes teaching practice in schools; at the end of their course of study, prospective teachers complete a one-year practicum and are evaluated by school supervisors, as well as by staff from their teacher education institutions.

Requirements for Ongoing Professional Development

Practicing teachers are expected to update their content knowledge and pedagogical skills by attending professional development programs offered by the Ministry of Education's Training and Development Department. This training is provided in a specialized training center by ministry officials and academic staff from institutions which also offer teacher education programs. Primarily, 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.

Monitoring Student Progress in Mathematics and Science

At the primary level (Grades 1–5), students are promoted to the next grade automatically. In Grades 1–3, an achievement file is used to evaluate student achievement and 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 and also has been criticized by parents. At the intermediate and secondary levels, students are required to pass examinations to gain promotion to the next highest grade. For Grades 4–9, the school year is divided into four periods (quarters), and standardized tests are held at the end of the second and fourth periods at the school district level. Students are promoted to the next grade if they obtain 50 percent of the total grade in every subject. If students fail three or more subjects, they take a second test in these subjects at the beginning of the following year.

At the secondary level, the academic year also is divided into four periods. In the first and third periods, tests are held at the school district level. In the second and fourth periods, national standardized tests are administered in all public and private schools in Kuwait.

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.

Final exams in the secondary stage are carried out at the ministry level in Grades 10–12. Under this system, students accumulate final examination grades based on their performance in Grades 10 (10%), 11 (30%), and 12 (60%), instead of on a single summative examination. For Grades 10 and 11, these tests are scored in schools through a system of collective correction, whereby there is a control room in each school, and students' names are kept confidential. For Grade 12, exams are scored at the national level, and the technical supervisors and teachers responsible for scoring gather in one place to complete the correction process. Names of students and their schools are kept confidential (i.e., replaced by identification numbers).

Students in Kuwait also have participated in three large-scale studies using standardized tests: the Progress in International Reading Literacy Study (PIRLS), which assessed reading literacy at Grade 4 in 2001, 2006, and 2011; the Kuwait National Assessment of Learning Outcomes, which assessed achievement in Grades 4 and 8 in Arabic, English, Islamic studies, mathematics, and science; [4] and TIMSS 1995 through 2007. The PIRLS 2006 findings revealed, among other things, that students in Kuwait were more likely than students in other countries to skip questions.[5] The first Kuwait National Assessment of Learning Outcomes found overall low achievement in mathematics, especially in one district (*Al-Jahra*).[6] It also indicated a high level of teacher dissatisfaction with their occupation and poor relations between teachers and parents.

Impact and Use of TIMSS

Kuwait first participated in TIMSS 1995, and was the only Arab country to participate in that year. Kuwait has since participated in TIMSS in 2007 and now 2011.

Educators and officials at the state level are interested in studying TIMSS results to determine the reasons for Kuwaiti students' poor performance. In light of TIMSS results, a political decision was made to revise mathematics and science curricula. In 2008, the enhanced mathematics and science curricula were implemented. These new curricula are translations of the American Scott Forresman Series, which were adapted to be compatible with Kuwaiti culture.

Suggested Readings

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