Russian Federation

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Introduction

Overview of Education System

According to the federal law *On Education in the Russian Federation*, passed in 2012, the government guarantees citizens of the Russian Federation free general education and free vocational education on a competitive basis at state and municipal educational institutions.

According to this law, federal authorities are responsible for the development and implementation of unified education policy, regional authorities are responsible for the development and implementation of regional programs, and local authorities are responsible for organizing education at different levels according to federal standards. Federal education authorities create federal policy, oversee its implementation, and develop the legislative basis for the functioning of the education system. Furthermore, federal authorities establish federal and state education standards and develop model curricula and programs of study for school subjects based on these standards. Federal authorities also oversee expert review of textbooks and supplementary literature for schools.[1]

The public system of education comprises general education at the preprimary, primary, basic, and upper secondary levels, and vocational education at the secondary, higher, and postgraduate levels. General education (Grades 1 to 11) is compulsory according to the Constitution of the Russian Federation.

Preprimary education is for children ages 2 months to 6 years, 6 months, and is not compulsory. In 2019, preprimary education was provided in 47,800 kindergartens serving 7.6 million children; 1,069 kindergartens are private.

Primary general education comprises Grades 1 to 4 and may be provided in primary schools, in basic schools that include the primary stage, and in secondary education institutions that include all three stages. Basic general education or lower secondary education comprises Grades 5 to 9, and secondary general or upper secondary education comprises Grades 10 and 11. Because general education is compulsory, students who finish basic school (Grade 9) and wish to attend vocational school will study general education subjects (equivalent to Grades 10 and 11, but at a basic level) as well as vocational education subjects and skills.

Approximately 99 percent of all primary, basic, and secondary schools in Russia are public-municipal, meaning that the municipal budget is the school's main source of funding, and many decisions are made at the regional level. At the beginning of the 2018–2019 school year, there were 40,498 public-municipal institutions and 851 nonpublic general education institutions serving 16.14 million students in Russia.[2]

The main innovations in general education in the last decade include the following:

- Federal State Education Standards were introduced in 2011 for primary schools and in 2015 for basic schools, emphasizing requirements that pertain to curriculum structure; student achievement in personal, metacognitive, and academic subject domains; and conditions for curriculum implementation. The requirements that pertain to student achievement can be considered competency-based.
- Beginning in 2013, new conceptual frameworks were approved for mathematics (2013), Russian language and literature (2016), social sciences (2018), technology (2018), art (2018), geography (2018), physics (2019), chemistry (2019), and astronomy (2019). These frameworks include basic principles, goals, tasks, and directions for the development of general education in Russia.
- In 2018, the National Education Project (2019–2024) was initiated with the aim of achieving two key goals: (1) to ensure the global competitiveness of the Russian education system and Russia's ranking among the top 10 countries leading the world in general education quality and (2) to ensure the development of socially responsible individuals on the basis of moral values and historical, cultural, and national traditions. The project comprises four key strategies for the education system development: updated content, a modern infrastructure, teacher professional development, and efficient management. The National Education Project[a] comprises the following initiatives:
  - Modern School—The introduction of new teaching methods and modern education technologies
  - Success of Every Child—A system for identifying, supporting, and developing the abilities and talents of children and youth, aimed at self-determination and professional guidance
  - Support Families with Children—The development of early childhood education, from birth to 3 years, and implementation of psychological, pedagogical, methodological programs for parents of children who receive preschool education at home
  - Digital Education Environment—A safe and modern digital education environment, with high quality and accessible education of all types and levels
  - Teacher of the Future—A national system for teacher professional development
  - Young Professionals—The modernization of vocational education including the introduction of adaptive, practice-oriented, and flexible educational programs

[a] https://edu.gov.ru/en/national-project/

- New Opportunities for Everyone—A system that encourages employees to update their professional knowledge and acquire new professional skills, including competence in a digital economy
- Social Engagement—A system that encourages employees to update their professional knowledge and acquire new professional skills, including competence in digital economy
- Export of Education—An initiative to increase the number of foreign citizens studying in universities and scientific organizations, and implementation of measures for their employment
- Social Mobility for Everyone—A system of professional competitions that give citizens opportunities for professional and career growth[3]

In 2019, the Ministry of Education of Russia initiated a new project—Monitoring the Development of Functional Literacy of Students—that teaches students to use the knowledge, abilities, and skills they acquire throughout life to solve the widest possible range of life tasks in various fields of human activity. The results of this project will inform educational and methodological recommendations for teachers on the development of students' functional literacy.

Use and Impact of TIMSS

The Russian Federation's participation in IEA studies is important to evaluating the quality of education in the country. Since 2005, the country's participation in international studies has been stipulated by the Federal Program for Education Development, adopted by the State Duma, and financed through the federal budget.

Since 2015, results of the Russian students participating in TIMSS (together with the results in the Progress in International Reading Literacy Study [PIRLS] and the Programme for International Student Assessment [PISA]) have been used as official indicators of the development of Russia's general education system. Since 2019, they have served as an indicator of Russia's ranking and for comparing Russia with the top 10 countries leading in the world in general education quality.

In recent years, the use of TIMSS data has been expanded. More and more specialists in multiple areas have started to use the data and have initiated secondary analyses. Specifically, TIMSS data have been used for the following:

- Informing audiences (e.g., policymakers, teachers, researchers, and students)
- Explaining results and planning new studies (e.g., using secondary analyses of TIMSS data)
- Developing new conceptual frameworks for mathematics and science education (2013–2019)
- Developing new problem solving and inquiry tasks
- Training specialists in educational measurement and data analysis at the federal and regional levels

- Developing new master's degree programs in educational measurement and evaluation, including a course called International Comparative Studies in Evaluation of the Quality of Education, in which students work with TIMSS data sets and conduct data analyses

The Mathematics Curriculum in Primary and Lower Secondary Grades

For all three stages of general education (Grades 1 to 11), the mathematics national curriculum stipulates the goals of mathematics education, the requirements for student achievement at the end of each stage of general school, and the instructional content that must be presented to ensure the achievement of these requirements.

The goal of mathematics education in primary school is the mathematical and general intellectual development of students, with special attention given to the formation of the ability to solve various problems using mathematics.

Fourth grade students who participated in TIMSS 2019 were taught in accordance with the Federal State Education Standard of Primary General Education (issued in 2009, introduced beginning in Grade 1 in 2011, and updated in 2015)[4] and the Model Basic Educational Program of Educational Institutions—Primary School, issued in 2011 and also updated in 2015.[5] The model program for mathematics in Grades 1 to 4 prescribes the basic content of mathematics instruction and the expected student outcomes (i.e., requirements for the attainment of primary school graduates). Although the model program defines the basic mathematics content and skill objectives, more detailed curricula are written for specific textbooks.

The objectives for student achievement are presented in two categories: objectives all primary school students are required to master, and objectives all primary school students have the opportunity to learn but are not required to master.

The program includes new mathematical content (e.g., fractions of the type $1/n$, spatial geometric shapes, and creation and verification of the truth of statements), as well as the following new content areas:

- Numbers and Magnitude, which focuses on formation of the understanding of concepts
- Working with Word Problems, which emphasizes the ability to solve problems
- Working with Information, which contains elements of descriptive statistics related to working with tables and charts, material of great practical significance for orientation in everyday life

Exhibit 1 presents the recommended mathematics content for primary school students.

Exhibit 1: Mathematics Content for Primary School, Grades 1 to 4

Topic Area	Recommended Content
Numbers and Values	Reading and writing numbers from 0 to 1 million; classes and categories; units of measurement of weight (grams, kilograms, hundredweight, and tons), capacity (liters), and time (seconds, minutes, and hours); comparing and ordering homogeneous quantities; and fractions (1/2, 1/3, 1/4, 1/10, 1/100, 1/1000)
Arithmetic Operations	Naming the components of arithmetic operations; addition and multiplication tables; the relationship among the arithmetic operations; finding unknown components of arithmetic operations; division with a remainder; numeric expressions (determining the order of operations and solving); using the properties of arithmetic operations in calculations (permutations and grouping terms in a sum, factors in a product, multiplying a sum and difference by a given number); algorithms of written operations (addition, subtraction, multiplication, and division of multidigit numbers); methods of verifying computations (e.g., algorithms, reverse calculation, reliability assessment, estimation, and using a calculator)
Solving Word Problems	Solving word problems by arithmetic methods; solving problems involving the relationships “more (or less) on” and “more (or less) in”; dependencies between quantities describing movement, work, purchase and sale, etc.; speed, time, and distance; measuring work, time, and labor productivity; quantity of goods, including their price and value; planning solutions to a problem; representing information using charts, tables, and other models; and finding parts of a whole and a whole based on its parts
Spatial Relations and Geometric Figures	Corresponding arrangements of objects in space and on a plane; recognizing and depicting geometric figures including points, line segments (curved and straight), broken lines, angles, polygons, triangles, rectangles, squares, circumference, and circles; using drawing tools to perform constructions; geometric shapes in the world; recognizing and naming cubes, spheres, parallelepipeds, pyramids, cylinders, and cones
Geometric Quantities	Geometric quantities and their measurement; measuring length of a segment; units of length (mm, cm, dm, m, km); perimeter; calculating perimeter of a polygon; area of geometric figures; units of area (cm^2, dm^2, m^2); exact and approximate measurement of area of geometric figures; calculating area of a rectangle
Working with Information	Collecting and representing information related to counting and measurement; recording and analyzing information; drafting simple expressions using the logical connectives and words “and,” “no,” “if ... then,” “true or false,” “every,” “all,” and “some”; verifying the truth of statements; drafting finite sequences of objects, numbers, geometric figures, etc., according to a rule; drawing up, writing, and executing simple algorithms, planning for information retrieval; reading, completing, and interpreting data in a table; reading bar graphs; creating simple information models (e.g., diagrams, tables, and chains)

By the end of primary education, student achievement in mathematics must meet the requirements presented in Exhibit 2.

Exhibit 2: Mathematics Requirements for Primary School, Grades 1 to 4

Topic Area	Basic Learning Requirements	Additional Learning Opportunities
Numbers and Values	Read, write, and compare numbers up to 1 million; establish rules for number sequences and write sequences according to a given or a self-determined rule; group numbers according to given or self-determined criteria; classify numbers according to one or more criteria and explain; and read, write, and compare quantities (e.g., mass, time, length, area, and speed)	Select units of measurement for given quantities (e.g., length, mass, area, and time) and explain
Arithmetic Operations	Carry out written calculations (i.e., addition, subtraction, multiplication, and division of numbers up to 10,000 into one-digit and two-digit numbers) using addition and multiplication tables and algorithms of written arithmetic operations (including division with a remainder); perform oral addition, subtraction, multiplication, and division on one-, two-, and three-digit numbers within 100 (including 0 and the number 1); solve arithmetic operations for unknown components; calculate the value of a numeric expression (containing 2 or 3 arithmetic operations, with and without brackets)	Perform operations with known quantities; use the properties of arithmetic operations to perform calculations; verify calculations using reverse action, estimation, assessment of results, etc.
Working with Word Problems	Use mathematics to represent the relationship between given quantities in a problem, develop a plan for solving the problem, and explain the chosen strategy; apply arithmetic methods to solving educational problems (1 to 2 steps) and problems in everyday life; solve problems involving fractions (1/2, 1/3, 1/4, 1/5, 1/10); verify solutions step by step and evaluate how realistic they are	Solve problems in 3 to 4 steps; find multiple ways to solve a problem
Spatial Relations and Geometric Figures	Describe the relative position of objects in space and in the coordinate plane; recognize, name, and represent geometric figures (e.g., points, lines, broken lines, right angles, polygons, triangles, rectangles, squares, circles, and circumference); construct geometric shapes with specified dimensions (e.g., lines, squares, and rectangles) with a ruler and a set square; use the properties of rectangles and squares to solve problems; recognize and name geometrical solids (e.g., cubes and spheres); and relate real world objects to models of geometric shapes	Recognize, distinguish, and name geometric solids (e.g., parallelepipeds, pyramids, cylinders, and cones)

Topic Area	Basic Learning Requirements	Additional Learning Opportunities
Geometric Quantities	Measure the length of a segment; calculate the perimeter of a triangle, a rectangle, and a square, and the area of a rectangle and a square; approximate (by eye) the size of geometric objects and distances	Calculate the perimeter of a polygon and the area of a figure made up of rectangles
Working with Information	Read and fill in simple tables; read simple bar graphs; understand simple expressions containing logical connectives and words (e.g., "and," "if ... then," "true or false," "every," "all," "some," and "no")	Read simple pie charts; complete simple bar graphs; draw, write, and execute instructions (e.g., easy algorithms); plan a search for information; recognize the same information presented in different forms (e.g., tables and charts); plan simple research, and collect and present the information using tables and charts; interpret the information obtained through simple research (e.g., explain, compare, and summarize data, draw conclusions, and make forecasts)

The eighth grade students who participated in TIMSS 2015 studied in accordance with the Federal State Education Standard of Basic General Education (Grades 5 to 9) issued in 2010.[6] The Model Basic Educational Program of Educational Institutions, based on the Federal State Education Standard was published in 2011 and implemented in 2015, beginning in Grade 5.[7] This program pays special attention to the development of universal educational skills (regulative, cognitive, communicative) within each academic subject, the practical orientation of the course, the use of Information and Communications Technology (ICT) tools, and acquiring experience in project activities as a special form of educational work. In the field of mathematics, the role of independent activity has been strengthened, including the independent discovery of new facts. Special attention is paid to mathematical modeling, the universality of the mathematical language, the use of mathematics to solve practical problems related to everyday life, and problems based on material from other educational subjects, using reference materials or a computer if necessary.

Mathematics courses in Grades 5 to 6 and algebra and geometry in Grades 7 to 9 combine both historically established concepts (numerical, algebraic, geometric, functional, etc.) and relatively new concepts (statistics and probability, real mathematics). Word problems and linear representations are presented separately. A logic section has been introduced; it is embedded in various mathematics and computer science courses and preceded by an introduction to the elements of set theory.

The Model Basic Educational Program defines the main content of the mathematics course and requirements for most graduates of basic schools. Textbook authors have developed more detailed programs based on this program.

Exhibit 3 presents the mathematics content that students in Grades 5 to 9 are expected to master.

Exhibit 3: Content of Mathematics Course, Grades 5 to 9

Topic Area	Content
Arithmetic	▪ The natural series of numbers and its properties; actions with natural numbers; rounding; properties and signs of divisibility; fractions, percentages, rational numbers, irrational numbers, real numbers; word problems; estimation and evaluation
Algebra	▪ Algebraic expressions; properties of exponents; operations with monomials, polynomials (addition, subtraction, multiplication); rational fractional expressions; operations with algebraic fractions (addition, subtraction, multiplication, division, exponentiation); conversion expressions containing the sign of the module; square roots ▪ Equations and inequalities; linear equations and their roots; linear equations with parameters; quadratic equations and their roots; quadratic equations with parameters; solution of rational fractional equations; methods for solving equations (methods of equivalent transformations, variable replacement method, graphical method); using the properties of functions in solving equations; the simplest irrational equations of the form $\sqrt{(f(x))} = a, \sqrt{(f(x))} = \sqrt{(g(x))}$; equations of the form $xn = a$; equations in integers. ▪ Systems of equations; equations with two variables; linear equations with two variables; methods for solving systems of linear equations with two variables (graphical, addition, and substitution methods); systems of linear equations with parameters ▪ Inequalities and solving linear inequalities; square inequalities and their solutions; solving integer and rational fractional inequalities using the interval method; systems of inequalities ▪ Linear function and quadratic functions; inverse proportionality; function graphs; properties of the function $y = \frac{k}{x}$; graphs of functions $y = a + \frac{k}{(x+b)}, y = \sqrt{x}, y = \sqrt[3]{x}, y = \lvert x \rvert$ ▪ The concept of asymptotes; continuity of function; piecewise defined functions; transformation of the graph of the function $y = f(x)$ to plot the functions of the form $y = af(kx + b) + c$; sequences and progressions
Word Problems	▪ Tasks for all arithmetic operations; tasks for movement, work, and shopping; tasks for parts, proportions, percentages; solving problems involving finding part of a number and a number from its part; solving problems involving percentages and proportions; using proportions to solve problems; logical tasks; the main methods of solving word problems (arithmetic, algebraic, enumeration of possibilities); primary ideas about other methods of solving problems (geometric and graphical methods)
Geometry	▪ Geometric shapes in geometry and the world; lines, line segments, straight lines, rays, polygonal lines, planes, angles, polygons, triangles, quadrangles, circumferences, and circles ▪ Geometric figures in space (three-dimensional bodies), visualization of spatial figures (primary understanding of a pyramid, parallelepiped, prism, sphere, full-sphere, cylinder, cone) ▪ Relationships and equality of figures, parallel lines, perpendicular lines, similarity ▪ Measurements and calculations; values, tools for measurements, and constructions; measurement and calculation of angles, lengths (distances), and areas; calculating the elements of triangles using trigonometric relations ▪ Geometric transformations; axial and central reflection; rotation and parallel translation; combinations of movements on a plane and their properties; vectors and plane coordinates
Elements of Logic, Combinatorics, Statistics, and Probabilities	▪ Evidence, sets, and combinatorics; tabular and graphical presentation of data, descriptive statistical indicators of numerical sets, dispersion measures; random events, probabilities of random events, experiments with equally possible elementary events; the idea of independent events in life
History of Mathematics	▪ The emergence of mathematics as a science, the stages of its development ▪ The main sections of mathematics ▪ Outstanding mathematicians and their contributions to the development of science

Exhibit 4 presents the mathematics achievement requirements for students in basic education in Grades 5 to 9.

Exhibit 4: Mathematics Requirements for Basic Education, Grades 5 to 9

Key Facts and Methods	
Know or Understand	▪ Mathematical proofs and the concept of algorithms ▪ How to use mathematical formulas, equations, and inequalities to solve mathematical and practical problems ▪ The probabilistic character of many laws of the natural world ▪ Examples of statistical regularities and conclusions ▪ How geometry has arisen from practical geodetic problems ▪ Examples of geometric objects and statements that are relevant to educational and real life problems
Arithmetic	
Be Able to	▪ Carry out arithmetic operations orally ▪ Convert numbers from one form to another ▪ Compare and carry out arithmetic operations with rational numbers ▪ Solve simple expressions with an integer exponent and roots ▪ Solve numerical expressions ▪ Find approximations with integers and decimals ▪ Use basic units of length, weight, time, speed, area, and volume; and solve word problems, including problems involving ratio and proportion, fractions, and percentages
Use Acquired Knowledge and Skills in Practical Activities and Daily Life to	▪ Estimate the results of calculations in solving practical problems ▪ Compare numbers in real situations ▪ Make numerical expressions when solving practical problems and tasks from other subjects
Algebra	
Be Able to	▪ Perform simple transformations to calculate the values of numerical expressions containing powers with a natural exponent, with an integer negative exponent; perform simple transformations of integer expressions, fractionally linear expressions, and expressions with square roots ▪ Solve linear inequalities and simple inequalities that reduce to linear; solve systems of simple linear equations, inequalities; solve quadratic equations using formula of the roots of the quadratic equation; depict solutions of inequalities and their systems on the number line ▪ Find the value of a function by the given value of the argument; find the value of the argument for the given value of the function in simple situations; according to a graph; find the domain, the set of values, the zeros of the function, the intervals of constant sign, the intervals of increase and decrease, and the largest and smallest values of the function; properties and graphs of linear functions; properties and graphs of quadratic functions; checking whether a given graph is a graph of a given function (linear, quadratic, inverse proportionality) ▪ Operate with concepts: sequence, arithmetic progression, geometric progression; solve problems on a progression in which the answer can be obtained by direct calculation without applying formulas

Algebra	
In Everyday Life and in the Study of Other Subjects	▪ Understand the meaning of writing numbers in a standard way and operating with the concept of "standard number notation" ▪ Calculate using formulas and write formulas expressing the relationship between real data ▪ Find the necessary formulas in the reference materials ▪ Simulate practical situations and explore the constructed models using algebraic methods (make and solve linear equations when solving problems arising in other subjects) ▪ Use the graphs of real processes and dependencies to determine their properties (largest and smallest values, intervals of increase and decrease, areas of positive and negative values, etc.) ▪ Use the properties of a linear function and its graph when solving problems from other educational subjects
Word Problems	
Be Able to	▪ Solve simple story problems of various types for all arithmetic operations ▪ Solve problems of finding part of a number and a number of its parts ▪ Solve problems of various types (for work, for purchases, for movement) connecting three quantities ▪ Distinguish these quantities and the relationship between them ▪ Find a percentage of a number, a number by a percentage of it ▪ Find a percentage decrease or percentage increase in a value ▪ Solve simple logical problems by reasoning
In Everyday Life and in the Study of Other Subjects	▪ Put forward hypotheses about the possible limit values of the quantities sought in the problem (make an estimation)
Geometry	
Be Able to	▪ Geometric figures ▪ Operate with the concepts of geometric figures ▪ Extract information about geometric figures presented in the drawings in an explicit form ▪ Solve problems of finding geometric quantities by exemplars or algorithms ▪ Relationships ▪ Operate with concepts: equality of figures, equal figures, equality of triangles, parallel lines, perpendicularity of lines, angles between lines, perpendicular, slanting line, projection. ▪ Measurements and calculations ▪ Measure lengths, distances, and angles using tools for measuring lengths and angles ▪ Apply the formulas of perimeter, area, volume, and surface area of some polyhedra in the calculations, when all the data are available ▪ Apply the Pythagorean theorem and basic trigonometric relations to calculate lengths, distances, and areas in the simplest cases ▪ Geometric constructions ▪ Represent typical flat shapes and figures in space by hand and using tools ▪ Geometric transformations ▪ Draw a figure symmetrical to the given figure with respect to the axis and point ▪ Vectors and coordinates on the plane ▪ Operate with the concepts of a vector, the sum of vectors, the product of a vector by a number, coordinates on the plane; approximate the coordinates of a point from its image on the coordinate plane

Geometry	
In Everyday Life and in the Study of Other Subjects	▪ Use the properties of geometric shapes to solve typical problems that arise in situations of everyday life, tasks of practical content ▪ Use relationships to solve simple, real life problems ▪ Calculate distances on terrain in standard situations, areas in simple cases, apply formulas in simple situations in everyday life ▪ Perform simple constructions on the ground, necessary in real life ▪ Recognize the movement of objects in the world, symmetrical figures in the world ▪ Use vectors to solve simple problems of determining the speed of relative motion
Elements of Logic, Combinatorics, Statistics and Probabilities	
Be Able to	▪ Perform simple proofs; draw elementary conclusions from statements ▪ Evaluate the logic of reasoning, using examples to illustrate and counterexamples to refute a statement ▪ Extract information from tables, charts, and graphs; create tables, charts, and graphs ▪ Solve combinatorial problems by systematically sorting out options and using the multiplication rule ▪ Determine the basic statistical characteristics of numerical sets ▪ Calculate average value ▪ Calculate frequency of events using personal observations and the statistics provided; estimate the probability of simple random events
In Everyday Life and in the Study of Other Subjects	▪ Conduct evidence verbally ▪ Recognize logically incorrect reasoning; write down mathematical statements and evidence ▪ Analyze real numerical data presented in charts, graphs, and tables ▪ Solve practical problems associated with everyday and professional life, using actions with numbers, percentage, length, area, volume, time, and speed ▪ Solve educational and practical problems that require a systematic enumeration of possible options ▪ Compare the probability of occurrence of random events ▪ Evaluate the probability of real random events in practical situations and compare models with real situations; understand statistical statements
History of Mathematics	
Be Able to	▪ Characterize the contribution of outstanding mathematicians to the development of mathematics and other scientific fields ▪ Understand the role of mathematics in the development of Russia

The Science Curriculum in Primary and Lower Secondary Grades

In primary education (Grades 1 to 4), science education is provided through a course called the Surrounding World, which integrates science with social studies (approximately 70 percent science content).

The new 2009 Federal State Education Standard of Primary General Education emphasizes student objectives of mastering content knowledge and skills, metasubject skills, and personal characteristics. These objectives are reflected in the new science curriculum, which requires teachers to take into account all three aspects of student competency when organizing the learning process.

The Federal State Education Standards describe the following general requirements pertaining to student achievement in science. After completing the Surrounding World, students will have attained the following competencies:

- Be able to expand, organize, and deepen original ideas about natural and social objects and phenomena as components of a unified world; master the basics of practice-oriented knowledge of nature, man, and society; and acquire a holistic view of the world in its organic unity and diversity of nature, peoples, cultures, and religions
- Gain experience of emotional and personal relatedness to nature and human culture; learn about the beginnings of integrated natural and social-humanitarian sciences and make connections that will support the understanding of personal experience, of surrounding world phenomena, and of their place in the environment
- Get acquainted with some of the ways to study nature and society; begin to develop the ability to conduct observations in nature; experience, see, and understand cause and effect relationships in the outside world and the inevitability of change under powerful leaders (e.g., in the culture of their home country) in a way that will help students master the basic skills of adaptation in a dynamically changing and developing world
- Acquire basic ICT skills; retrieve information from verifiable online and electronic sources; learn to create messages in text, audio, and video formats; and create and deliver small-scale presentations
- Adopt and embrace the social role of learner, characterized by motivation to learn; develop a personal understanding of learning, self-reliance, responsibility, and developing guidelines for research and information sharing based on moral norms, social justice, and freedom

After completing this course, students will have a foundation of environmental and cultural literacy and be able to observe best practices in nature and society, ensuring a healthy lifestyle and sustainable conduct toward the environment.

The Model Basic Educational Program of Educational Institutions presents detailed objectives for science at two levels: "Graduates will learn to" and "Graduates will have the opportunity to learn to." Exhibit 5 presents these levels.

Exhibit 5: Science Requirements for Primary School, Grades 1 to 4

Humans and Nature	
Graduates (Grade 4 Students) will Learn to	▪ Recognize objects and phenomena in living and nonliving nature ▪ Describe the essential features of objects and phenomena in living and nonliving nature ▪ Compare objects in living and nonliving nature based on external features or known characteristics and carry out the simplest classification of these objects ▪ Conduct simple environmental observations and experiments using simple laboratory equipment and measuring instruments; follow instructions and safety regulations when conducting observations and experiments ▪ Use scientific texts (paper and electronic formats, including the internet with controlled access) to find and retrieve information, answer questions, find explanations, and create original oral or written statements ▪ Use a variety of reference books (e.g., dictionaries of science, illustrated field guides for plants and animals, maps, and computer publications) to search for necessary information ▪ Use ready-made models (e.g., globes, maps, and plans) to explain phenomena or describe the properties of objects ▪ Discover the basic relationship between living and nonliving nature, as well as relationships in nature, and use these to explain the need for respecting nature ▪ Determine the nature of the relationship between man and nature, and find examples of the impact of this relationship on natural sites and human health and safety ▪ Understand the need for a healthy lifestyle and respect for the rules of safe behavior; use knowledge about the structure and functions of the human body to maintain and improve their health
Graduates (Grade 4 Students) Will Have the Opportunity to Learn to	▪ Use tools (photo and video cameras, microphones, etc.) to record and process information, and to present the results of observations and experiments ▪ Simulate objects and real world processes using virtual laboratories and instruments, collected from the manufacturers ▪ Understand the value of nature and the need for people to take responsibility for its maintenance, to observe the rules of ecological behavior at school, at home (e.g., separate garbage collection, save water and electricity), and in nature ▪ Use self-control to preserve health; adhere to a regimen of nutrition and personal hygiene ▪ Comply with the rules of safe behavior at home, on the street, and in nature; provide first aid in the case of simple accidents ▪ Plan, monitor, and evaluate activities in the process of learning about the world in accordance with assigned tasks and the conditions of their implementation

Exhibit 6 presents the science content for primary education (Grades 1 to 4).

Exhibit 6: Science Content for Primary Education, Grades 1 to 4

Topic Area	Content
Nature	Natural objects and manmade objects; nonliving and living nature; features of objects (color, shape, size, etc.); examples of natural phenomena (i.e., seasonal changes, snowfall, falling of the leaves, the flight of birds, changing time of day, sunrise, sunset, wind, rain, and thunderstorms)
Substances	A variety of substances in the surrounding world; examples of substances (i.e., salt, sugar, water, and natural gas); solids, liquids, and gases; simple experimentation with solids, liquids, and gases
Stars and Planets	The Sun as our nearest star, the source of light and warmth for all living things on Earth; Earth as a planet, the formation and dimensions of Earth; the globe as a model of Earth; geographic maps and plans; Earth's continents and oceans, their names and locations on a map; the most important natural features in students' home country and region; orienteering; the compass; alternation of night and day; the rotation of Earth as the cause of day and night; the seasons and their characteristics (based on observation); the changing of the seasons in students' local environment on the basis of observation
Weather	Weather, the components of weather (e.g., air temperature, cloudiness, precipitation, wind), and monitoring weather
Earth's Structure	The shape of Earth's surface: plains, mountains, hills, ravines (general concepts, symbols of plains and mountains on a map); surface features in students' local environment (brief description on the basis of observation); water basins, their diversity (e.g., oceans, seas, rivers, lakes, and ponds), and their uses; local bodies of water (names, brief characteristics on the basis of observation); air (gas mixture, properties of air, and the value of air for plants, animals, and humans); water (properties of water, states of water, water distribution in nature, the value of water for living organisms and human economic life, and the water cycle in nature); minerals, their importance in human life, and responsible attitudes toward minerals; fossils found in the local environment (two or three examples); and soil, its composition, and its value for wildlife and for human life
Plants	The diversity of plants; parts of a plant (e.g., root, stem, leaf, flower, fruit, seed); the conditions necessary for plant life (e.g., light, heat, air, water); monitoring plant growth; trees, bushes, and grasses; wild and cultivated plants; the role of plants in nature and human life; and plants in the local environment, their name, and a brief description on the basis of observation
Mushrooms	Edible and poisonous mushrooms; rules for collecting mushrooms
Animals	The diversity of animals; the conditions necessary for animal life (e.g., air, water, heat, and food); insects, fish, birds, and beasts, and the differences among them; the feeding habits of various animals (i.e., carnivorous, herbivorous, and omnivorous); animal reproduction (insects, fish, birds, and mammals); wild and domestic animals; the role of animals in nature and human life; responsible attitudes toward animals; and animals in the local environment, their names, and brief descriptions based on observation
The Unity of Living and Nonliving Nature	The unity of living and nonliving nature in forests, meadows, and ponds (sunlight, air, water, soil, plants, animals); cycles of substances; the natural zones of Russia: general understanding and the main natural areas (climate, flora and fauna, particularly labor and welfare, human impact on nature, conservation of nature); humans as part of nature; the dependence of human life on nature; the ethical and aesthetic value of nature in human life; mastering the laws of nature through hands-on activities; the folk calendar (signs, sayings, proverbs) and how it defines the seasonal work of people; positive and negative effects of human activities on nature; rules of behavior in nature; the protection of natural resources (water, air, minerals, flora and fauna); nature reserves, national parks, and their role in nature conservation; the Red Book of Russia, its value, and some representatives of plants and animals in the Red Book; participation in nature conservation; and personal responsibility for safety in nature

Topic Area	Content
The Human Body	Understanding the structure of the human body; organ systems (musculoskeletal, digestive, respiratory, circulatory, nervous, sensory) and their role in the life of an organism; hygiene of organ systems; measuring body temperature and pulse rate; taking responsibility for your health and the health of people around you; maintaining a respectful attitude toward people with disabilities and caring for them

Science education in basic school (Grades 5 to 9) begins with the integrated course Nature Study in Grade 5 and is followed by individual science subjects: biology (Grades 6 to 9), geography (Grades 6 to 9), physics (Grades 7 to 9), and chemistry (Grades 8 to 9).

Eighth grade students who participated in TIMSS 2019 studied in accordance with the Federal State Education Standard of Basic General Education (Grades 5 to 9) issued in 2010 and introduced for science from Grade 5 in 2015, similar to mathematics.

The standards for science emphasize the importance of metacognitive and metasubject skills and personal development, as well as the acquisition of basic content knowledge and skills when studying school subjects, working on projects, and participating in extracurricular activities related to science. The new standards make the science education environment in basic school more open to and reflective of student interests and abilities.

According to the Federal State Education Standard of Basic General Education, the study of the subject area Natural Science should provide:

- The formation of a holistic scientific picture of the world
- An understanding of the growing role of natural sciences and scientific research in the modern world, the ongoing process of evolution of scientific knowledge, the importance of international scientific cooperation
- Mastery of the scientific approach to solving various problems
- Mastery of the ability to formulate hypotheses, design, conduct experiments, and evaluate results
- Mastery of the ability to compare experimental and theoretical knowledge with the objective realities of life
- Development of a responsible and respectful attitude toward the environment
- Mastery of the ecosystem cognitive model and its application to forecast environmental risks to human health, life safety, and environmental quality
- Awareness of the importance of sustainable development
- The formation of skills for the safe and efficient use of laboratory equipment, accurate measurements, and an adequate assessment of the results obtained, and the presentation of evidence-based arguments for their actions, based on an interdisciplinary analysis of educational tasks

Exhibit 7 presents the science content for basic education (Grades 5 to 9) for all science subjects by the main topics studied, given in the Model Basic Educational Program of Educational Institutions.

Exhibit 7: Recommended Science Content for Basic Education, Grades 5–9

Topic Area	Concepts
Biology	▪ Science, cell structure, and variety of living organisms; living environments; organs of a flowering plant, microscopic structure of plants, vital activity of flowering plants, plant variety; bacteria; fungus; unicellular animals, or protozoa, intestinal protozoa; worms, shellfish, arthropods, chordates ▪ Introduction to Human Sciences: general properties of the human body; neurohumoral regulation of body functions; regulation of body functions, function regulation mechanisms; propulsion and movement; circulation, respiration, and digestion; metabolism and energy; selection; reproduction and development; sensory systems (analyzers); higher neurological activity; human health and protection ▪ General biological patterns ▪ Biology as a science; cells, organisms, species, ecosystems
Geography	▪ Geographical knowledge of the Earth; Earth in the universe; Earth's movements and their consequences; image of the Earth's surface; nature of the Earth; humanity on Earth; human development of the Earth; main laws of the nature on Earth; description of Earth's continents; interaction of nature and society ▪ Territory of Russia on the world map; general characteristics of the nature of Russia; natural and territorial complexes of Russia; population of Russia ▪ Geography of your area; economy of Russia; regions of Russia ▪ Russia in the world
Physics	▪ Physics and physical methods of studying nature; mechanical, thermal, electromagnetic, and quantum phenomena; structure and evolution of the universe
Chemistry	▪ Initial chemical concepts; oxygen, hydrogen, water, solutions ▪ The main classes of inorganic compounds; structure of an atom; Mendeleev's periodic law and periodic system of chemical elements ▪ The structure of substances; chemical bonds; chemical reactions ▪ Nonmetals of Groups IV to VII and their compounds; metals and their compounds; initial Information on organic substances

For all science subjects, the Model Basic Educational Program of Educational Institutions includes the detailed knowledge and skill requirements for basic school graduates. For the sake of brevity, Exhibit 8 presents only the basic school achievement requirements for chemistry as an example. The requirements for student achievement are formulated in two categories: objectives all basic school students are required to master, and objectives all basic school students have the opportunity to learn but are not required to master. The objectives of the second category are not included in the student attestation at the end of Grade 9.

Exhibit 8: Chemistry Requirements for Basic Education, Grades 8 to 9

Competency Level	Objectives
Graduates (Grade 9 Students) Will Learn to	▪ Characterize the basic methods of cognition: observation, measurement, experiment ▪ Describe the properties of solid, liquid, gaseous substances, highlighting their essential features ▪ Disclose the meaning of the basic chemical concepts of atom, molecule, chemical element, simple substance, complex substance, valency, chemical reaction using the sign system of chemistry ▪ Disclose the meaning of the laws of conservation of mass of substances, constancy of composition, atomic-molecular theory ▪ Distinguish between chemical and physical phenomena ▪ Name the chemical elements ▪ Determine the composition of substances by their formulas ▪ Determine the valency of an atom of an element in compounds ▪ Determine the type of chemical reactions ▪ Name the signs and conditions of chemical reactions ▪ Identify signs indicative of a chemical reaction during a chemical experiment ▪ Produce the formulas of binary compounds ▪ Formulate equations describing chemical reactions ▪ Comply with the rules of safe operation when conducting experiments ▪ Use laboratory equipment and utensils ▪ Calculate the relative molecular and molar masses of substances ▪ Calculate the mass fraction of a chemical element by the formula of the compound ▪ Calculate the amount, volume, or mass of a substance by the amount, volume, mass of reactants, or reaction products ▪ Characterize the physical and chemical properties of simple substances: oxygen and hydrogen ▪ Receive and collect oxygen and hydrogen ▪ Recognize experimentally gaseous substances including oxygen, hydrogen ▪ Know the meaning of Avogadro's law ▪ Understand thermal reaction effect, and molar volume ▪ Characterize the physical and chemical properties of water ▪ Disclose the meaning of the concept of solution ▪ Calculate the mass fraction of solute in solution ▪ Prepare solutions with a certain mass fraction of solute ▪ Name the compounds of the studied classes of inorganic substances ▪ Characterize the physical and chemical properties of the main classes of inorganic substances: oxides, acids, bases, salts ▪ Determine the affiliation of substances to a particular class of compounds ▪ Make the formulas of inorganic compounds of the studied classes ▪ Conduct experiments confirming the chemical properties of the studied classes of inorganic substances ▪ Recognize empirical solutions of acids and alkalis by changing the color of the indicator ▪ Characterize the relationship between classes of inorganic compounds ▪ Disclose the meaning of Mendeleev's Periodic Law ▪ Explain the physical meaning of the atomic (ordinal) number of the chemical element, group, and period numbers in Mendeleev's periodic system

Competency Level	Objectives
	▪ Explain the laws of changes in the structure of atoms, the properties of elements within small periods and main subgroups ▪ Characterize chemical elements (from hydrogen to calcium) based on their position in Mendeleev's periodic system and structural features of their atoms ▪ Construct diagrams of the structure of atoms of the first 20 elements of Mendeleev's periodic system ▪ Disclose the meaning of chemical bond, electronegativity ▪ Characterize the dependence of the physical properties of substances on the type of crystal lattice ▪ Determine the type of chemical bond in inorganic compounds ▪ Depict the structure of the molecules of substances formed by different types of chemical bonds ▪ Disclose the meaning of ion, cation, anion, electrolytes, non-electrolytes, electrolytic dissociation, oxidizing agent, oxidation state, reducing agent, oxidation, reduction ▪ Determine the oxidation state of an atom of an element in a compound ▪ Disclose the meaning of the theory of electrolytic dissociation ▪ Make equations of electrolytic dissociation of acids, alkalis, salts ▪ Explain the essence of the process of electrolytic dissociation and ion exchange reactions ▪ Compile complete and abbreviated ionic equations of the exchange reaction ▪ Determine the possibility of ion exchange reactions ▪ Carry out reactions confirming the qualitative composition of various substances ▪ Determine the oxidizing agent and reducing agent ▪ Construct equations of redox reactions ▪ Name the factors affecting the speed of a chemical reaction ▪ Classify chemical reactions according to various criteria ▪ Characterize the relationship between the composition, structure, and properties of nonmetals ▪ Conduct experiments on the receipt, collection, and study of the chemical properties of gaseous substances: carbon dioxide, ammonia ▪ Recognize experimentally gaseous substances including carbon dioxide and ammonia ▪ Characterize the relationship between the composition, structure, and properties of metals ▪ Name organic substances by their formula: methane, ethane, ethylene, methanol, ethanol, glycerin, acetic acid, aminoacetic acid, stearic acid, oleic acid, glucose ▪ Evaluate the effect of chemical environmental pollution on the human body ▪ Competently handle substances in everyday life ▪ Determine the possibility of reactions of some representatives of organic substances with oxygen, hydrogen, metals, bases, halogens

Competency Level	Objectives
Graduates (Grade 9 Students) Will Have the Opportunity to Learn to	▪ Put forward and test hypotheses on the chemical properties of substances based on their composition and structure, their ability to enter into chemical reactions, on the nature and products of various chemical reactions ▪ Characterize substances by composition, structure, and properties; establish causal relationships between these characteristics of the substance ▪ Make molecular and complete ionic equations using abbreviated ionic equations ▪ Predict the ability of a substance to exhibit oxidizing or reducing properties, taking into account the degree of oxidation of the elements included in its composition ▪ Produce the equations of reactions corresponding to the sequence of transformations of inorganic substances of various classes ▪ Put forward and test experimentally hypotheses about the effects of various factors on the change in the rate of a chemical reaction ▪ Use the acquired knowledge for environmentally sound behavior in the environment ▪ Use the acquired key competencies in the implementation of projects and educational research tasks to study the properties, methods of obtaining and recognizing substances ▪ Objectively evaluate information about substances and chemical processes ▪ Critically evaluate pseudoscientific information, advertising in the media ▪ Recognize the importance of theoretical knowledge in chemistry for the practical activities of humans ▪ Create models and schemes for solving educational and cognitive tasks, understand the need to comply with the requirements proposed in the instructions for the use of medicines, household chemicals, etc.

Professional Development Requirements and Programs

New professional standards for teachers issued in 2013 began to be implemented from 2017 to 2019. These standards aim to expand teachers' professional competencies, change the educational environment and the criteria of evaluating teachers' work, and as a result, increase the quality of education in Russia.

The key idea of the new professional standards is the ability to work with different categories of children, including gifted, disabled, disadvantaged, or orphaned children, among others. According to the new professional standard, a teacher must master the following new competencies: technologies for working with gifted people; technologies for working with an inclusive education program; and the capability to work with students with developmental, social, and behavioral challenges.

Professional development is no longer compulsory and is being reoriented to align with new education goals. This process involves a change in emphasis from subject content to student development, such that teachers are receiving more training in active learning strategies and child development. Teachers also are being taught to use ICT in the learning process.

Monitoring Student Progress in Mathematics and Science

National and Regional Examinations

To attain a basic general education certificate, students must pass four examinations: two compulsory national examinations in mathematics and Russian, and two examinations in subjects they select. Certificates are awarded based on the results of the compulsory examinations only. Students may choose to take additional examinations in other subjects depending on university admission requirements. Examinations in science subjects are not compulsory, although students in Grades 9 and 11 may choose to take examinations in any science subject.

National examinations at the end of secondary education, known as Unified State Examinations (USE), were introduced in 2009, combining the general secondary education graduate examinations with higher education entrance examinations. These examinations as well as the national examinations administered upon graduation from basic school are prepared centrally by test developers from the Federal Institute of Educational Measurement.

In 2015, the USE in mathematics was divided into two independent examinations—basic and profile. Basic examinations are for students who do not plan to go to university or who plan to apply to universities that do not require special qualifications in mathematics; profile examinations are for students planning to apply to universities that require special qualifications in mathematics.

In addition to the national examinations, a school may set examinations in any subject at any grade of basic or secondary education. These exams may be administered in oral or written form and may include multiple-choice and short response or extended response questions and essays.

The introduction of federal education standards has changed the procedure for school accreditation, increased the role of student assessment, and changed the emphasis slightly from separate assessments of subject knowledge to integrated assessments of mathematic and scientific literacy and the nature of science knowledge and skills.

With the aim of identifying talented students interested in mathematics and science, more Olympiads and other competitions in these subjects have been organized. In the last decade, more attention has been focused on project and investigation results, with an integrative nature, than on subject knowledge acquired.

Monitoring Individual Student Progress

Schools administer formative and summative assessments to ensure consistency of student achievement with the curriculum requirements and to diagnose student progress. Schools decide the timing and form of these assessments. Assessment results sometimes are used for teacher or school accreditation. Generally, summative assessment takes place at the end of each school year in each school subject. Assessment formats include oral examinations, short answer, extended response or essay questions, and multiple choice tests. Schools usually use individual teacher-made tests, locally developed tests, or tests developed centrally and published as special supplementary materials.

Innovations in assessment arising from general education reform include the introduction of a qualitative system of assessment without grades or marks in primary school and a shift in the orientation of assessment from absolute achievement to the dynamics of student achievement throughout primary and basic school.

Special Initiatives in Mathematics and Science Education

After the introduction of the new conceptual framework for the development of mathematics education in the Russian Federation, approved in 2013,[8] the new conceptual frameworks for development of science education were issued from 2018 to 2019.[9] They include basic principles, goals, tasks, and directions for the development of science education in Russia.

One of the bases for modernization of science education is the results of the Russian students in TIMSS. Comparison of TIMSS science tests for Grade 4 with the national curriculum shows a significant discrepancy both in the volume of the studied content (fewer substantive units in Grade 4 in Russia) and in the content of individual topics. For example, in physical sciences, in the Russian program there are fewer large topics: energy sources, thermal phenomena, light and sound phenomena, electrical and magnetic phenomena, forces and motion.

The results of TIMSS for Grade 8 indicate an imbalance in the cognitive processes: the highest results are achieved among Russian students when they are reproducing knowledge and applying it in typical situations; deficits are recorded when students are applying knowledge in changed situations, explaining phenomena, describing observations, and analyzing data.

TIMSS data also indicates a small number of students studying advanced physics and, accordingly, a lack of specialized physics and mathematics classes.

The main directions of the implementation of the new frameworks for science education are as follows:

- In primary school—The introduction of the new content and change of the emphasis of learning on observation, experimentation, description of phenomena, assumptions about their causes
- In basic school—The introduction of an integrated course in natural sciences in Grades 5 to 6, modernization of systematic courses of science subjects in Grades 7 to 9, introduction of advanced courses in Grades 8 to 9 for students interested in this field, and development of special technical creativity programs increasing children's interest in science
- Modernization of the learning process: cognitive activation, computer-based modeling and data analysis, personalized learning, and students' cooperation in learning
- In assessments—Increased use of experimental and inquiry tasks, science literacy tests; introduction of computer-based assessment; improved dynamics in students' achievement and motivation

- Teacher training—Working with children at different levels of achievement, interest, socioeconomic status, functional literacy (science literacy, reading literacy, creativity and critical thinking, etc.); using computerized learning and assessment

Initiatives at the federal and regional levels mainly tend to include support for high achieving students (e.g., the organization of special centers for talented students by region with a federal center in Sochi) and for developing regional quality assessment systems with an emphasis on supporting the learning process (e.g., in the Krasnojarsk Kraj region or Jamalo-Nenetsky Okrug).

Suggested Reading

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