

Republic of Korea

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Introduction

Overview of Education System

The Ministry of Education (MOE) is responsible for the formulation and implementation of policies related to academic activities and public education. The specific responsibilities of MOE include the following:

- Planning and coordinating education policies
- Formulating policies that govern primary, secondary, and higher education institutes
- Publishing and approving textbooks
- Providing administrative and financial support for all levels of the school system
- Supporting local education offices and national universities
- Operating the teacher training system
- Overseeing lifelong education
- Developing human resource policies

With the enactment of the Local Education Autonomy Act in 1991, education administration became decentralized, and the MOE delegated much of its budget planning and administrative decisions to metropolitan and provincial offices of education. These offices make decisions regarding education, art, and science pertaining to each metropolitan and provincial area. The superintendent, who is the head of the education office, is elected every four years. As of 2016, there are 17 metropolitan and provincial offices of education as well as 176 district offices of education.¹

Korea has a single-track, 6–3–3–4 system that can be divided as follows:

- Six years of elementary school (primary grades)
- Three years of middle school (lower secondary grades)
- Three years of high school (secondary grades)
- Four years of college or university

Elementary and middle school education is compulsory and free. Moreover, since 2019, the MOE has been phasing in free noncompulsory high school education, a process that is due to be complete by 2021.

Use and Impact of TIMSS

Korea has been participating in TIMSS since 1995. Although TIMSS results have impacted education policies and reforms only moderately, both education researchers and policymakers have continually tried to benchmark and refer to TIMSS results when developing national curricula and education policies. For example, since TIMSS 1995, it has been an important goal to foster positive attitudes among students toward mathematics and science due to the low interest and confidence they had previously shown in those two subjects, despite their generally high levels of attainment. To accomplish this goal, the Comprehensive Plan for Mathematics Education (2015) was implemented, with the aim of fostering positive attitudes toward mathematics by connecting the subject more to real-life contexts and encouraging inquiry-based learning.² The Comprehensive Plan for Science Education (2016) was also established, with the aim of encouraging students to participate more actively in class with increased interest and confidence in science.³

The Mathematics Curriculum in Primary and Lower Secondary Grades

Korean fourth grade students who participated in TIMSS 2019 had studied under the 2009 mathematics curriculum in Grades 1 to 3 and the 2015 curriculum in Grade 4, whereas the eighth grade students who participated in TIMSS 2019 had studied under the 2007 mathematics curriculum in Grades 1 to 3 and the 2009 curriculum in Grades 4 to 8.⁴ Therefore, we provide information about the 2009 and 2015 mathematics curricula below. The 2009 mathematics curriculum aims to:

- Develop students' ability to understand mathematical skills, concepts, principles, and laws, including their interrelationships, through the experience of mathematically observing, analyzing, organizing, and representing everyday social and natural phenomena.
- Enhance students' ability to think and communicate mathematically, and use those skills to develop the ability to solve mathematical problems in rational and creative ways.

Help students understand the value of mathematics by fostering intrinsic motivation, interest in mathematics, and a generally positive attitude toward mathematics.⁵

The 2009 mathematics curriculum emphasized mathematical processes, such as mathematical problem solving, communication, and reasoning. According to the curriculum, the mathematical process involves not only the useful instructional method of improving students' understanding but also the reinforcement of mathematical content. In addition, the 2015 mathematics curriculum emphasized that students should not only understand and acquire mathematical knowledge and skills, but also cultivate six mathematical competencies: problem solving; reasoning; creativity and integration; communication; information processing; and attitude and practice.⁶

The 2009 mathematics curriculum for elementary school categorized content into the following five domains: Numbers and Operations; Figures; Measurement; Patterns; and Probability and Statistics. The 2009 mathematics curriculum for middle school also had five domains: Numbers and Operations; Variables and Expressions; Functions; Probability and Statistics; and Geometry. Exhibits 1 and 2 concisely summarize the content elements in an individual grade band in the 2009 mathematics curriculum. In addition, the content elements for elementary school in the 2015 mathematics curriculum are categorized into the following five domains: Number and Operations; Shapes; Measurement; Patterns; and Data and Chance. Exhibit 3 summarizes the content elements in an individual grade band in the 2015 mathematics curriculum.

Exhibit 1: Topics Covered in Grades 1 to 6 in the 2009 Mathematics Curriculum

Domain	Content Elements		
	Grades 1 to 2	Grades 3 to 4	Grades 5 to 6
Numbers and Operations	<ul style="list-style-type: none"> ▪ Numbers of up to four digits ▪ Addition and subtraction of two-digit numbers ▪ Multiplication 	<ul style="list-style-type: none"> ▪ Five-digit and higher numbers ▪ Addition and subtraction of three-digit numbers ▪ Multiplication ▪ Division ▪ Four arithmetic operations with natural numbers ▪ Fractions ▪ Decimals ▪ Addition and subtraction of fractions and decimals 	<ul style="list-style-type: none"> ▪ Factors and multiples ▪ Addition and subtraction of fractions ▪ Multiplication and division of fractions ▪ Multiplication and division of decimals ▪ Fractions and decimals
Figures	<ul style="list-style-type: none"> ▪ Shapes of solid figures ▪ Shapes of plane figures ▪ Plane figures and their components 	<ul style="list-style-type: none"> ▪ The fundamentals of figures ▪ Moving plane figures ▪ The components of a circle ▪ Triangles ▪ Quadrangles ▪ Polygons 	<ul style="list-style-type: none"> ▪ Congruence and symmetry ▪ Cuboids and cubes ▪ Prisms and pyramids ▪ Cylinders and cones ▪ Solid figures and spatial sense
Measurement	<ul style="list-style-type: none"> ▪ Comparing quantities ▪ Telling time ▪ Moment and length of time ▪ Length 	<ul style="list-style-type: none"> ▪ Time ▪ Length ▪ Volume ▪ Weight ▪ Angles ▪ Estimation (rounding off, rounding up, rounding down) ▪ Scope of numbers (equal to or greater than, equal to or less than, greater than, less than) 	<ul style="list-style-type: none"> ▪ The perimeter and area of a plane figure ▪ Units of weight and area ▪ The ratio of the circumference of a circle to its diameter and the area of circles ▪ Surface area and volume

Domain	Content Elements		
	Grades 1 to 2	Grades 3 to 4	Grades 5 to 6
Patterns	<ul style="list-style-type: none"> ▪ Looking for patterns 	<ul style="list-style-type: none"> ▪ Looking for patterns ▪ Patterns and correspondence 	<ul style="list-style-type: none"> ▪ Ratio and rate ▪ Proportional expressions and distribution ▪ Direct and inverse proportions
Probability and Statistics	<ul style="list-style-type: none"> ▪ Classifying ▪ Drawing tables ▪ Drawing graphs 	<ul style="list-style-type: none"> ▪ Organizing data ▪ Bar and broken-line graphs 	<ul style="list-style-type: none"> ▪ Chance and averages ▪ Expressing data ▪ Ratio graphs (band graphs and pie charts)

Exhibit 2: Topics Covered in Grades 7 to 9 in the 2009 Mathematics Curriculum

Domain	Content Elements		
	Grades 7 to 9		
Numbers and Operations	<ul style="list-style-type: none"> ▪ Prime factorization ▪ Greatest common factor, least common multiple ▪ Concepts, comparison, and four basic operations of integers and rational numbers 	<ul style="list-style-type: none"> ▪ Recurring decimals ▪ Relationship between rational numbers and recurring decimals 	<ul style="list-style-type: none"> ▪ Concept and properties of square roots ▪ Irrational numbers ▪ Comparison of real numbers ▪ Four basic operations of expressions with radicals
Variables and Expressions	<ul style="list-style-type: none"> ▪ Using variables ▪ Value of expressions ▪ Addition and subtraction of linear expressions ▪ Linear equations 	<ul style="list-style-type: none"> ▪ Law of exponents ▪ Addition and subtraction of polynomials ▪ Multiplication and formulas of multiplication of polynomials ▪ Division of polynomials ▪ Modification of equations ▪ Simultaneous linear equations ▪ Properties of inequalities and linear inequalities ▪ Simultaneous linear inequalities 	<ul style="list-style-type: none"> ▪ Factorization ▪ Quadratic equations
Functions	<ul style="list-style-type: none"> ▪ Concept of functions ▪ Ordered pairs and coordinates ▪ Graph of functions 	<ul style="list-style-type: none"> ▪ Meaning and graphs of linear functions ▪ Application of linear functions ▪ Relationship between linear functions and linear equations 	<ul style="list-style-type: none"> ▪ Meaning of quadratic functions ▪ Properties of graph of quadratic functions

Domain	Content Elements		
	Grades 7 to 9		
Probability and Statistics	<ul style="list-style-type: none"> ▪ Stem-and-leaf plots, frequency distribution tables, histograms, frequency distribution polygons ▪ Average from frequency tables ▪ Distribution of relative frequency 	<ul style="list-style-type: none"> ▪ Number of events ▪ Concept and properties of probability ▪ Calculation of probability 	<ul style="list-style-type: none"> ▪ Median, mode, average ▪ Variance, standard deviation
Geometry	<ul style="list-style-type: none"> ▪ Points, lines, faces, angles ▪ Positional relationships between points, straight lines, and planes ▪ Properties of parallel lines ▪ Constructing triangles ▪ Conditions for congruent triangles ▪ Properties of polygons ▪ Relationships between central angle and arc in sectors ▪ Length of arcs and area in sectors ▪ Properties of polyhedrons and solids of revolution ▪ Surface area and volume of solid figures 	<ul style="list-style-type: none"> ▪ Properties of isosceles triangles ▪ Circumcenter and incenter of a triangle ▪ Properties of quadrilaterals ▪ Properties of similar figures ▪ Conditions for similar triangles ▪ Length and ratio of parallel line segments ▪ Application of properties of similar figures 	<ul style="list-style-type: none"> ▪ The Pythagorean theorem ▪ Trigonometric ratios ▪ Properties of chords and tangents of a circle ▪ Properties of a circumferential angle

Exhibit 3: Topics Covered in Grades 1 to 4 in the 2015 Mathematics Curriculum

Domain	Content Elements		
	Core Concepts	Grades 1 to 2	Grades 3 to 4
Numbers and Operations	The number system	<ul style="list-style-type: none"> ▪ Numbers up to four digits 	<ul style="list-style-type: none"> ▪ Five-digit and higher numbers ▪ Fractions ▪ Decimals
	Numerical operations	<ul style="list-style-type: none"> ▪ Addition and subtraction of two-digit numbers ▪ Multiplication 	<ul style="list-style-type: none"> ▪ Addition and subtraction of two-digit numbers ▪ Multiplication and division of natural numbers ▪ Addition and subtraction of fractions with same denominator ▪ Addition and subtraction of decimals

Domain	Content Elements		
	Core Concepts	Grades 1 to 2	Grades 3 to 4
Shapes	Plane figures	<ul style="list-style-type: none"> ▪ Shapes of plane figures ▪ Plane figures and their components 	<ul style="list-style-type: none"> ▪ Foundation of shapes ▪ Components of a circle ▪ Triangles ▪ Quadrilateral figures ▪ Polygons ▪ Moving plane figures
	Solids	<ul style="list-style-type: none"> ▪ Shapes of solids 	
Measurement	Measurement of quantity	<ul style="list-style-type: none"> ▪ Comparing quantities ▪ Time and time intervals ▪ Length (cm, m) 	<ul style="list-style-type: none"> ▪ Time, length (mm, km), capacity, weight, angles
Patterns	Patterns and correspondence	<ul style="list-style-type: none"> ▪ Identifying patterns 	<ul style="list-style-type: none"> ▪ Demonstrating the patterns in numbers and equations
Data and Chance	Data processing	<ul style="list-style-type: none"> ▪ Classifications ▪ Tables ▪ Graphs using symbols \circ, \times, / 	<ul style="list-style-type: none"> ▪ Simple picture graphs ▪ Bar graphs ▪ Line graphs

The Science Curriculum in Primary and Lower Secondary Grades

Korean fourth grade students who participated in TIMSS 2019 had studied under the 2009 science curriculum in Grade 3 and the 2015 science curriculum in Grade 4. The eighth grade students who participated in TIMSS 2019 had studied under the 2007 science curriculum in Grade 3 and the 2009 science curriculum in Grades 4 to 8. The 2009 and 2015 science curricula were both designed to help students to develop scientific literacy, which encompasses scientific knowledge and processes for scientific and creative problem-solving in daily life. However, the goals for the science curriculum were revised for the 2015 version. The goals of science education in the 2009 science curriculum were to help students:

- Understand basic scientific concepts through inquiry into natural phenomena
- Increase interest in and curiosity about natural phenomena
- Develop scientific thinking skills and creative problem solving abilities
- Recognize interrelationships between science, technology, and society⁷

On the other hand, in the 2015 science curriculum, the goals were revised with an emphasis on expanding scientific inquiry into students' daily lives and society in general. The 2015 science curriculum also aimed to help students develop lifelong learning skills based on recognition of the joy and value of learning science.⁸

To achieve their curricular goals, both the 2009 and 2015 science curricula emphasize inquiry-based learning and students' active participation in scientific inquiry, which involves various epistemic practices, such as observation, experimentation, investigation, and discussion. Rather than merely acquiring knowledge, both curricula emphasize a comprehensive understanding of basic scientific concepts and the development of the ability to solve everyday problems

scientifically. In the 2009 science curriculum, teachers are encouraged to use group activities as well as individual activities in the science classroom, so that students can develop communicative abilities and scientific aptitudes that include elements such as critical thinking, openness, integrity, objectivity, and collaboration. The 2015 science curriculum cultivates five competencies that can explicitly delineate the performances of students who achieve the curricular goals: scientific thinking skills; scientific inquiry abilities; scientific problem-solving ability; scientific communication skills; and engagement in science and lifelong learning ability.

Both the 2009 and 2015 science curricula cover elements of physics, chemistry, biology, and Earth science. In the primary and lower secondary levels of the 2009 science curriculum, the contents were categorized into two domains: Matter and Energy, and Life and Earth. In the 2015 science curriculum, there was a reorganization of contents in an attempt to emphasize the interdisciplinary aspects of the four branches, rather than introducing science as the sum of four separate branches. The contents were reorganized into core concepts; they are considered “core” in the sense that they have explanatory ability for other scientific concepts. The core concepts are grouped into broader areas. Moreover, the 2015 science curriculum suggests that core concepts and scientific inquiry should be taught systematically across multiple grade levels and in relation to one another in different areas. Exhibits 4 and 5 concisely summarize the content elements for individual grade bands in the 2009 science curriculum. Exhibit 6 shows the content covered in Grades 3 and 4 under the 2015 science curriculum.

Exhibit 4: Topics Covered in Grades 3 to 6 in the 2009 Science Curriculum

Domain	Content Elements			
	Grades 3 to 4		Grades 5 to 6	
Matter and Energy	<ul style="list-style-type: none"> ▪ Weights of objects ▪ Objects and matter ▪ Liquids and gases ▪ Properties of sound 	<ul style="list-style-type: none"> ▪ Use of magnets ▪ Separation of mixtures ▪ Mirrors and shadows ▪ State changes of water 	<ul style="list-style-type: none"> ▪ Temperature and heat ▪ Dissolution and solutions ▪ Acids and bases ▪ Speeds of objects 	<ul style="list-style-type: none"> ▪ Use of electricity ▪ Various gases ▪ Use of lenses ▪ Combustion and extinguishment
Life and Earth	<ul style="list-style-type: none"> ▪ Earth and the Moon ▪ Animal life cycles ▪ Animal life ▪ Changes in the Earth’s surface 	<ul style="list-style-type: none"> ▪ Plant life cycles ▪ Volcanoes and earthquakes ▪ Plant life ▪ Geological strata and fossils 	<ul style="list-style-type: none"> ▪ Weather and humans ▪ Plant structure and function ▪ The Solar system and the stars ▪ Structure and functions of the human body 	<ul style="list-style-type: none"> ▪ Motions of Earth and the Moon ▪ Living things and the environment ▪ Living things and humans ▪ Seasonal changes

Exhibit 5: Topics Covered in Grades 7 to 9 in the 2009 Science Curriculum

Domain	Content Elements				
	Grades 7 to 9				
Matter and Energy	What is science? (*cross-domain topic)	<ul style="list-style-type: none"> Force and motion Heat and humans Molecular motions and changes of state 	<ul style="list-style-type: none"> Composition of matter Light and waves Properties of matter Work-energy conversion 	<ul style="list-style-type: none"> Electricity and magnetism Patterns in chemical reactions Various chemical reactions 	Science and human civilization (*cross-domain topic)
Life and Earth		<ul style="list-style-type: none"> Earth systems and changes in lithosphere Photosynthesis Composition and circulation of the hydrosphere 	<ul style="list-style-type: none"> The atmosphere and humans Digestion, circulation, respiration and excretion Stimulation and response 	<ul style="list-style-type: none"> The Solar System Reproduction and development Heredity and evolution The exosphere and space development 	

Exhibit 6: Topics Covered in Grades 3 to 4 in the 2015 Science Curriculum

Area	Core Concepts	Content Elements
		Grades 3 to 4
Force and Motion	Force	<ul style="list-style-type: none"> Weight Horizontal balance Working principle of spring balance
Electricity and Magnetism	Magnetism	<ul style="list-style-type: none"> Magnetic force Properties of magnets
Wave	Types of waves	<ul style="list-style-type: none"> Sound generation Sound intensity Sound pitch Sound transmission Light traveling in a straight line Shadows
	Properties of wave	<ul style="list-style-type: none"> Plane mirrors Reflection of light
Properties of Matter	Physical and chemical properties	<ul style="list-style-type: none"> Objects and matter Nature of matter Function of objects Change of matter Mixtures Separation of mixtures Filtration Evaporation

Area	Core Concepts	Content Elements
		Grades 3 to 4
	State of matter	<ul style="list-style-type: none"> ▪ Solids, liquids, and gases ▪ Weight of gases
Change of Matter	Change of states	<ul style="list-style-type: none"> ▪ Change of states of water ▪ Evaporation ▪ Boiling ▪ Condensation
Life Science and Human Life	Biotechnology	<ul style="list-style-type: none"> ▪ Examples of mimicry by animals and plants in daily life
Continuity of Life	Reproduction	<ul style="list-style-type: none"> ▪ Life cycle of animals ▪ Complete and incomplete metamorphosis ▪ Life cycle of plants ▪ Germination conditions of seeds ▪ Male and female animals ▪ Male and female animals' various reproductive behaviors
	Evolution and diversity	<ul style="list-style-type: none"> ▪ Animals and plants in diverse environments ▪ Structural features of animals and plants ▪ Classification of animals ▪ Classification of plants
Solid Earth	Earth system and force field	<ul style="list-style-type: none"> ▪ The environment of the Earth
	Plate tectonics	<ul style="list-style-type: none"> ▪ Volcanic activity ▪ Earthquakes ▪ Countermeasures against earthquakes
	Composition of earth	<ul style="list-style-type: none"> ▪ Creation and conservation of soil ▪ Weathering and erosion ▪ Granitic and basaltic rocks ▪ Sedimentary rocks
	History of the Earth	<ul style="list-style-type: none"> ▪ Formation and characteristics of strata ▪ Fossil generation ▪ Extinct creatures and the environment
Atmosphere and Ocean	Properties and circulation of seawater	<ul style="list-style-type: none"> ▪ Characteristics of the ocean ▪ The water cycle
Universe	Composition and movement of the Solar System	<ul style="list-style-type: none"> ▪ Shape of Earth and the Moon ▪ Atmosphere of the Earth ▪ The environment of the Moon

Professional Development Requirements and Programs

In Korea, a variety of teacher development programs are provided, mostly at teacher training institutions affiliated with the metropolitan and provincial offices of education and universities. Induction programs are provided for newly appointed teachers for two weeks before they start teaching. The purpose of these programs is to enhance participants' understanding of education vision and policies, to enhance professionalism in areas such as classroom management and student counseling, and to raise expectations for the teaching profession and so prepare them to be a teacher.

Two types of in-service training are generally available for both primary and secondary school teachers: qualification training programs and expertise training programs.⁹ One of the qualification training programs is the Grade I certificate teacher program. To be a Grade I certificate teacher, in-service teachers with three or more years of teaching experience should take an intensive professional career development program lasting more than 90 hours during school vacation.¹⁰ The intensive programs mostly cover the following content areas: subject content knowledge; pedagogical knowledge; instructional strategies and assessment; leadership; and classroom management. Teachers with a Grade I certificate can be promoted to more senior positions. The program is not mandatory, but the majority of Korean teachers participate in it and gain the qualification.

Korean teachers are required to develop their expertise by participating in professional development programs that focus on upgrading their subject content knowledge, enhancing their subject teaching skills, and equipping them with new competencies in response to changing needs and demands. For example, secondary science teachers are required to participate in 30 to 60 hours of scientific experiment training to boost their expertise in the field of scientific experimentation. Middle school mathematics teachers are required to participate in programs about teaching statistics using technology, because the new mathematics curriculum has changed how statistics is taught. Science, technology, engineering, arts, and mathematics (STEAM) training programs are also provided to encourage teachers to enhance their ability to develop STEAM programs and teach their STEAM classes. Moreover, teachers can now make use of online training programs as well as traditional face-to-face professional development opportunities.

Monitoring Student Progress in Mathematics and Science

For quality control purposes, the National Assessment of Education Achievement (NAEA) is conducted annually. The NAEA has the following four aims:

- Assessing educational progress and achievement nationwide
- Monitoring the quality of education at the national level and the appropriateness of the national curriculum

- Collecting background information affecting educational achievement
- Providing information about achievement to students, teachers, parents, and the government

A sample of 9th and 11th grade students is chosen to represent the national population, and then the NAEA is administered to assess these students' achievement in Korean, mathematics, and English; science and social studies tests are also administered to the 9th grade students.¹¹

In some metropolitan areas and provinces, the education offices administer diagnostic assessment for students in Grades 4 to 9 and provide remedial programs to support students who are falling below the basic level of achievement in Korean, mathematics, English, science, and social studies.

At the classroom level, teachers evaluate students' achievement using various assessment tools and methods, including observing the students' activities, administering teacher-made tests, and reviewing homework or work output.

Special Initiatives in Mathematics and Science Education

In recent years, the MOE has unveiled two major plans: the Comprehensive Plan for Mathematics Education (2015) and the Comprehensive Plan for Science Education (2016). These plans set the goals and directions for education in their respective subjects as well as the policy tasks required to achieve them. The primary goal of both plans is to encourage students to enjoy learning mathematics and science, and to achieve this objective, the plans emphasized career development programs related to mathematics and science. In addition, they emphasize popularizing mathematics and fostering scientific culture. To this end, mathematics museums have been established, and various mathematics and science fairs have been held across the country.

In April 2018, the Science, Mathematics and Information Education Promotion Act (No. 14903, enacted in 2017), the revised law of the Science Education Promotion Act, was implemented. The aim of this act was to “prescribe matters necessary for promoting science, mathematics, and information education, which are core subjects to prepare for the change of the industrial environment, so as to contribute to enhancing national competitiveness and to national and social development by contributing to cultivating multidisciplinary persons of talent to lead our future.”

The act provides that the national government and regional authorities shall formulate policies to promote science, mathematics, and information education, which includes establishing and operating exhibitions and experience facilities related to these subjects (such as science and mathematics museums) and holding and supporting various events for young people that promote these subjects.¹²

In Korea, educational support for low-achieving students is provided to help them reach a basic level of academic attainment. For example, Do-Dream Schools now provide these students with integrated support, such as counseling services, personalized instruction, diagnosis of academic performance, and school consultations. The number of these schools is expected to reach 5,000 by

2022.¹³ In addition, Mathematics *Na-Num* Schools have a mathematics learning support system that helps low-achieving students with low interest and confidence in mathematics to achieve success in the subject. In the field of science education, the Ladder Projects provide science career experience programs and mentoring programs to underprivileged students who display scientific talent, so that they can grow up to be successful scientists regardless of their family background, gender, or any disabilities they might have.

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