Italy

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Introduction

Overview of Education System

The Italian Constitution recognizes and guarantees the right to education for all of its citizens.[1] It requires the state to maintain a public school system and allows the coexistence of state and nonstate schools.[2]

The Republic establishes general norms for education, and the overall responsibility for education lies with the Ministry of Education (*Ministero dell'Istruzione, dell'Università e della Ricerca* [*MIUR*]), which operates centrally and is responsible for organizing the various education levels and for managing the personnel in public schools and the curricula in both public and private schools.[3] At the local level, regions are responsible for vocational training; other responsibilities, such as the management of preprimary schools, are often delegated to provincial and municipal authorities. Schools have autonomy with regard to didactics, organization, research, experimentation, and development.[4]

Education is compulsory from 6 to 16 years of age or until a professional qualification is obtained.[5] The Italian school system is organized into preprimary education, followed by two education cycles. Preprimary education serves children 3 to 6 years of age and is not compulsory. The first cycle of education is divided into primary school (five years) and lower secondary school (three years). At the end of the first cycle of education, students are required to pass an exam to progress to upper secondary education or vocational training. A single curriculum, established at the national level, is common to all levels in the first cycle of education. The second cycle of education (five years) consists of upper secondary school and vocational education and training. *Lycees* (general schools), technical institutes, and vocational institutes are types of upper secondary schools and are governed by the state. Vocational training is provided by certified education and training agencies, which are governed at the regional level.[6]

The MIUR establishes the basic curriculum for all upper secondary school tracks (general, technical, and vocational). Mathematics is a fundamental discipline common to all schools, with curricular differences across the various tracks. Science is divided into separate school subjects (i.e., chemistry, physics, and biology), with differences also based on tracks; not all science subjects are taught in every type of school.

Recently, the *Sistema Nazionale di Valutazione* (*SNV*), or national evaluation system, was set up to steer school policies and to promote the full implementation of school autonomy. The *SNV* is responsible for evaluating the efficacy and efficiency of the whole school system and aims to improve the quality of education offered as well as student achievement.[7] Within the *SNV*, schools are required to submit a self-evaluation report annually based on a format established by the *MIUR* and to set up an improvement plan that is consistent with the improvement goals identified in the self-evaluation report.[8]

In Italy, the official language of instruction for all school subjects is Italian. In certain areas of the country populated by native speakers of other languages, local languages are used in school instruction. In particular, the state safeguards 12 minority languages spoken in certain regions of the country, but only four of them are legally recognized: French (in the Valle d'Aosta), Slovenian (in Friuli-Venezia Giulia), German (in the province of Bolzano), and Ladin (in Trentino-Alto Adige and the province of Trento).[9,10] In these regions, students may attend schools in which the language of instruction is the language of their respective linguistic minority.[11]

Use and Impact of TIMSS

The national assessment frameworks in Italy have been inspired by the TIMSS, PIRLS, and PISA frameworks and are updated continually based on these frameworks. In particular, the TIMSS and PIRLS frameworks have provided a crucial reference point, because they are strongly curriculum based, as national assessments should be.

To improve Italian student performance in international assessments, information and training sessions on international and national assessment (i.e., TIMSS, PIRLS, and PISA) and their results were offered to teachers of Italian, mathematics, and science at every school type and level in Italy, as well as to teachers of adult education, from 2010 to 2012. This training initiative had two strategic objectives: to increase student reading comprehension and mathematical skills and to reduce the student dropout rate by increasing the familiarity of teachers with the evaluation methodology applied in these assessments. Another aim of the initiative was to spread a culture of evaluation in primary and secondary schools by providing teachers with diversified tools and materials, including tests and scoring guidelines.[12]

To encourage the use of TIMSS data, schools participating in the TIMSS assessment are given a report with the main results, which are compared with the national and territorial benchmarks. A volume reporting secondary and in-depth research results of the PISA and TIMSS/TIMSS Advanced studies was published in 2019.[13]

The Mathematics Curriculum in Primary and Lower Secondary Grades

In 2012, the *MIUR* published the new *Indicazioni nazionali per il curricolo della scuola dell'infanzia e del primo ciclo di istruzione*, or national curricular guidelines for preprimary school and for the first cycle of education.[14] This document represents a framework for schools in the design and implementation of local primary and lower secondary curricula. Schools are free to determine the content and methods of instruction autonomously, provided that they are consistent with the learning objectives established by the *Indicazioni*. The curricular guidelines at the preprimary level and in the first cycle of education were updated by the *MIUR* in September 2012[15] and in 2018,[16] respectively. The learning objectives at the primary level correspond to the goals that students are expected to achieve by the end of their third and fifth years of primary education.[17] Exhibits 1 and 2 summarize the content areas and learning objectives in the mathematics curriculum at the primary level.[18]

Exhibit 1: Mathematics Learning Objectives at the 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 using common written algorithms ▪ Read, write, and compare decimal numbers (written without units, in monetary units, or as simple measurements), represent them on a number line, and perform simple addition and subtraction
Space and Shapes	▪ Be aware of one's position and be able to estimate distance and volume within a specified space ▪ Report the position of objects in physical space, relative to oneself and to other people or objects, using appropriate terms (e.g., above and under, in front of and behind, left and right, and inside and outside) ▪ Perform a simple procedure given a verbal description or drawing, describe the direction of one's movement in a defined space, and instruct others to follow a given direction ▪ Recognize, name, and describe geometric figures ▪ Draw geometric shapes and construct material models in space
Relations, Data, and Chance	▪ Classify numbers, figures, and objects according to one or more properties using contextual information and appropriate representations ▪ Explain the criteria used in ordering and classifying ▪ Read and represent relations and data with diagrams, charts, and tables ▪ Measure quantities (e.g., length, time) using arbitrary units or conventional instruments (e.g., ruler, clock)

Exhibit 2: Mathematics Learning Objectives at the End of Grade 5

Content Area	Objectives and Expectations
Numbers	▪ Read, write, and compare decimal numbers ▪ Perform arithmetic operations with confidence, evaluating and choosing a method of calculation (i.e., mental, written, or calculator) based on the context of a problem ▪ Perform division of natural numbers with remainders, and identify multiples and divisors of a number ▪ Estimate the result of arithmetic operations ▪ Work with fractions and recognize 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 ▪ Understand systems of numerical notation that are or were used in places, times, and cultures other than the present
Space and Shapes	▪ Describe, classify, and identify significant elements and symmetries of geometric figures, in a way that allows others to reproduce them ▪ Reproduce a figure, based on a given description and using appropriate instruments (e.g., graph paper, ruler, compass, squares, and geometry software) ▪ Use the Cartesian plane to locate points ▪ 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 ▪ Compare and measure angles using properties and instruments ▪ Use and distinguish concepts of perpendicular, parallel, horizontal, and vertical ▪ Reproduce a figure according to scale (e.g., on graph paper) ▪ Determine the perimeter of figures ▪ Determine the area of rectangles, triangles, and other figures by decomposition ▪ Recognize two-dimensional representations of three-dimensional objects, and identify different perspectives of the same object (e.g., top view, front view)
Relations, Measurement, Data, and Chance	▪ Represent relations and data, and use the representations to obtain information and make judgments and decisions ▪ Use notions of arithmetical mean, mode, and frequency, where appropriate to the type of available data ▪ Represent the structure of problems with graphs and tables ▪ Understand the common units of measurement for length, angles, area, volume, time, and mass or weight, and use them to make measurements and estimates ▪ Convert between units of measurement (including monetary units) ▪ Consider a pair of events, and explain which is more likely or recognize that both events are equally probable ▪ Recognize and describe patterns in a sequence of numbers or figures

Exhibit 3 summarizes the objectives and expectations of the mathematics curriculum at the lower secondary level.[19]

Exhibit 3: Mathematics Learning Objectives at the 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 using common written algorithms, calculators, and calculation tables, and evaluate which method is most suitable in a specific context ▪ Estimate the results of arithmetic operations and check the plausibility of calculations ▪ Represent numbers on a number line, use graded scales in science and technology contexts, and describe ratios and quotients using both decimals and 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 multiplication by a decimal number ▪ Identify multiples and divisors of natural numbers, and multiples and divisors common to several numbers ▪ Understand the meaning and applications of the least common multiple and greatest common divisor in mathematics and in other practical contexts ▪ Find prime factors of natural numbers and understand their applications ▪ Use positive whole exponents correctly, understanding their meaning, and 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 ▪ Know that the square root of 2 is an irrational number ▪ Perform simple mental calculations using associative and distributive properties to simplify arithmetic operations ▪ Express a sequence of operations with simple algorithms as a solution to a problem ▪ Correctly use rules governing order of operations with and without brackets ▪ Correctly express large numbers using scientific notation
Space and Shapes	▪ 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 plane figures (e.g., triangles, quadrilaterals, regular polygons, and circles) ▪ Describe complex figures and geometric constructions ▪ Reproduce geometrical figures and drawings according to a given description ▪ 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 area of simple figures by breaking them down into more elementary figures (e.g., triangles) or using the most common formulas ▪ Estimate the area of a figure consisting of curves by rounding ▪ Understand π , and some ways to approximate it ▪ Understand formulas used to find the area of a circle and the length of its circumference

Content Area	Objectives and Expectations
	▪ Know and use the main geometric transformations and their invariants ▪ Represent three-dimensional objects and plane figures in various ways (e.g., drawings on a plane) ▪ Visualize three-dimensional objects from two-dimensional representations, calculate volume of the most common three-dimensional figures, and estimate volume of everyday objects ▪ Solve problems using geometric properties of figures and solids
Relations and Functions	▪ Construct, interpret, and transform formulas containing variables to express relationships and properties ▪ Express proportionality using equivalent fractions (and vice versa) ▪ Use the Cartesian plane to represent relations and functions, to understand functions such as $y = ax, y = \frac{a}{x}, y = ax^2, y = 2n$, and their graphs, and to link $y = ax$ and $y = \frac{a}{x}$ to the concept of proportionality ▪ Explore and solve problems using first-degree equations
Measurement, 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 arithmetical mean, mode, and median; evaluate variability of a data set calculating range, for example ▪ Identify elementary events in simple random situations, assign a probability to them, calculate the probability of an event, and break it down into separate elementary events ▪ Recognize pairs of complementary, incompatible, or independent events

The Science Curriculum in Primary and Lower Secondary Grades

The curricular guidelines at the preprimary level and in the first cycle of education were updated by the *MIUR* in September 2012[20] and in 2018,[21] respectively. The science curriculum at the primary level is organized by identifying the content to be taught by the end of the third year (Grade 3) and by the end of the fifth year (Grade 5).[22] There is no specific curriculum for the end of the fourth year. Exhibits 4 and 5 summarize the learning objectives and expectations detailed in the science curriculum at the primary level.[23]

Exhibit 4: Science Learning Objectives at the End of Grade 3

Content Area	Objectives and Expectations
Exploring and Describing Objects and Materials	▪ Identify the structure of simple objects and materials through hands-on exploration, analyze their qualities and properties, describe them as a whole or in terms of their parts, deconstruct and reconstruct them, and recognize their functions and how to use them ▪ Order and classify objects and materials on the basis of their properties ▪ Identify tools and units of measurement appropriate to the problems being solved, take measurements, and use mathematics to manage the data ▪ Describe simple daily phenomena that occur with liquids, food, forces and movement, heat, etc.
Observing and Experimenting in the Field	▪ Observe the germination of plant life and the development of animal life through cultivating small animal farms in the classroom, sowing in terrariums or gardens, etc. ▪ Identify similarities and differences between animal and plant development ▪ Observe the characteristics of soil and water through field trips ▪ Observe and understand the environmental changes generated by nature (e.g., sun, weathering, water) and by mankind (e.g., urbanization, cultivation, industrialization) ▪ Be familiar with atmospheric phenomena (e.g., wind, clouds, rain) and with the periodicity of celestial phenomena (e.g., day and night, the sun's path in the sky, the seasons)
Man, Living Things, and the Environment	▪ Recognize and describe the environmental characteristics of the place where one lives ▪ Observe how one's own body works (i.e., hunger, thirst, pain movement, cold, heat), recognize it as complex organism, and suggest a simple working model for it ▪ Recognize needs in different living organisms, similar to those of mankind, with respect to their environment

Exhibit 5: Science Learning Objectives at the End of Grade 5

Content Area	Objectives and Expectations
Objects, Materials, and Transformations	▪ Observe and recognize certain scientific concepts in practical experience (e.g., spatial dimensions, weight, specific weight, force, movement, pressure, temperature, heat) ▪ Begin to recognize the regularity of phenomena and develop a basic understanding of energy ▪ Observe, use, and build simple measurement tools where possible (e.g., bowls to measure volume/capacity, spring balances), learning how to use conventional units of measurement ▪ Identify the properties of certain objects and materials (e.g., hardness, weight, flexibility, transparency, density); experiment with simple water solutions (e.g., water and sugar, water and ink) ▪ Observe and schematize phase changes of matter, building simple interpretative models and graphing relationships among identified variables (e.g., temperature versus time)
Observing and Experimenting in the Field	▪ Make frequent and regular observations in the local environment with the naked eye or using the appropriate tools, individually or with classmates; identify characteristics of the environment and how they change during observations ▪ Understand the composition of soil, exploring rocks, stones, and topsoil; observe the characteristics of water and its role in the environment ▪ Reproduce and understand the movement of objects in the sky, modeling them with body movement
Man, Living Things, and the Environment	▪ Describe and understand the functions of the human body as a complex system in a particular environment; configure realistic models of the systems of the human body and their functions; develop basic models of cell structure ▪ Care for personal health including diet and exercise; acquire basic knowledge about reproduction and sexuality ▪ Recognize the interdependence of organisms through exploration on plantations, farms, etc. ▪ Classify animals and plants based on the personal observation of basic characteristics ▪ Observe and understand environmental changes, including global changes, particularly those caused by mankind acting on the environment

Exhibit 6 summarizes the learning objectives and expectations detailed in the science curriculum at the lower secondary level.[24]

Exhibit 6: Science Objectives and Expectations at the End of Grade 8

Content Area	Objectives and Expectations
Physics and Chemistry	▪ Apply fundamental concepts of physics (e.g., pressure, volume, speed, weight, specific weight, force, temperature, heat, and electric charge) in different situations; collect data on relevant variables of different phenomena, define quantitative relationships, and depict them in formal representations of different types; conduct experiments that involve inclined planes, flotation, communicating vessels, heating water, melting ice, and building circuits (e.g., battery-switch bulb) ▪ Understand and apply the concept of conservation of energy; recognize its dependence on other variables; understand heat transfer; conduct experiments that involve watermills, dynamos, rotating propellers on a radiator, and heating water with a blender, for example ▪ Understand chemical transformation; conduct experiments that involve safe chemical reactions with household products (e.g., water solutions, candle combustion, baking soda and vinegar) and understand the reactions based on simple models of the structure of matter; observe and describe the reactions that occur mechanisms and the products yielded
Astronomy and Earth Science	▪ Model and understand celestial phenomena by observing the day and night skies and using planetarium or computer simulations; reconstruct Earth's movements that determine day and night and the changing of the seasons; reconstruct three-dimensional models from the history of astronomy ▪ Explain the mechanisms of solar and lunar eclipses, using simulations; design experiments that involve building a sundial and recording the sun's trajectory and its height at midday throughout the year ▪ Recognize the main types of rock and the geological processes that generate them through field research and hands-on exploration ▪ Know Earth's structure and its inner movements (plate tectonics); identify local seismic, volcanic, and hydrogeological risks to allow planning of prevention activities; conduct experiments, such as rock collecting
Biology	▪ Recognize similarities and differences among the functions of different living species ▪ Understand the classification of living things and recognize fossil evidence that contributes to understanding Earth's changes over time, ecological succession, and the evolution of species; conduct experiments that involve observing the diversity among individuals of the same species on a farm or with livestock, for example ▪ Gradually develop the ability to explain biological functions at the cellular level (e.g., explain breathing in terms of cell respiration, nutrition in terms of cell metabolism, growth and development in terms of cell duplication, plant growth in terms of photosynthesis); conduct experiments that involve dissecting plants, making cell models, observing plant cells using a microscope, and cultivating mold and microorganisms, for example ▪ Understand the biological basis of the transmission of hereditary characteristics and basic genetics ▪ Acquire knowledge about puberty and sexuality; develop personal health care and self-control with a healthy diet; consciously avoid smoking and drugs ▪ Behave and make personal choices in a way that is environmentally sustainable; respect and preserve biodiversity in the environment; conduct experiments that involve building nests for wild birds, or adopting a pond or a forest, for example

Professional Development Requirements and Programs

Newly employed teachers are required to complete 50 hours of compulsory training, 20 hours of which must be conducted through an online platform that was implemented in February 2016. In addition to offering training courses, the online platform aims to create a digital environment to facilitate communication, discussion, and exchange of materials among teachers during their first year of service.[25]

For tenured teachers, in-service training is mandatory, permanent and structural (paragraph 124 of Law 107 of 2015).[26] The priorities for teacher training are indicated in the National Training Plan.

This Plan is adopted every three years by decree of the Minister of Education, University and Research, after consultation with the trade unions. Each educational institution defines the training activities following the three-year plan of the training offer, and with the results emerging from the school improvement plans.

An improvement plan is a process of planning and development of actions based on the priorities indicated in the Self-evaluation Report (RAV) that each school has drawn upon ministerial indication. This process is based on the involvement of the entire school community and is based on two dimensions: teaching and management organization. The school manager is responsible for the management of the improvement process, assisted by guidance from the internal evaluation team. They decide on the contents, methods, procedures, and criteria for participation in the training, also taking into account teachers' individual needs and hours of service.

Monitoring Student Progress in Mathematics and Science

At both primary and lower secondary schools, teachers carry out periodic and annual assessments of student learning and grade students numerically on a 10-point scale.[27] At primary schools, student grades are accompanied by written analytical comments. In daily practice, teachers have the autonomy to determine how to assess students, and student evaluation at all school levels is conducted through oral, written, and practical testing (depending on the subject). For each period of evaluation, the teachers' board drafts report cards tracking student progress in each discipline. Teachers keep a register in which they record student marks and absences. Starting in the 2012–2013 school year, schools and teachers are expected to use online registers and to send communications to students and families in an electronic format.[28] To use these registers, schools must be equipped with computers or tablets—available to teachers for use in classrooms—with a wireless connection. For this reason, implementing the electronic register has taken more time, and to date, not all schools have been able to make use of it. In its essential functions, the online electronic register is equivalent to a traditional register; however, it offers greater opportunities for use. Its digital, online format helps optimize organizational and educational aspects of school life. It aims to simplify the bureaucratic management that teachers must carry out and to enable real

time communication with parents. Parents can follow their children's work from home through direct and transparent access to programs, grades, absences, and disciplinary actions. At the end of the school year, teachers copy average grades into a final report card.

Students graduate from primary to lower secondary school on the basis of an 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 three to four months) and at the end of each school year, subject teachers confer in a class council to determine final student grades. Subject teachers present student grades in their respective disciplines to the class council, and then, the council discusses and approves final student grades by majority vote. A grade of 6 out of 10 (equivalent to "satisfactory") is the minimum passing grade.

Since 2004, the National Institute for the Educational Evaluation of Instruction and Training (*INVALSI*) has sought to improve the quality of Italy's education system by administering national and international student assessments.[29] External assessments of student performance are administered in Grades 2 and 5 in primary school, Grade 8 in lower secondary school, and Grade 10 and Grade 13 in upper secondary school.[30] At the end of lower secondary school (Grade 8), all students take a state examination. If they obtain an overall grade higher than 6 out of 10, they earn the certificate required for matriculation in upper secondary education. At this stage, schools prepare their own final examinations in mathematics and science (on the basis of their curriculum). As of the 2008–2009 school year, the state examination includes the *INVALSI* tests for Italian and mathematics.[31] Students also receive periodic and annual evaluations of their conduct, graded numerically on a 10-point scale. Students must earn a grade of at least 6 out of 10 from the class council to advance to the next grade level, and in Grade 8, they must take the final lower secondary school examination.

Special Initiatives in Mathematics and Science Education

There are no special initiatives or national policies to encourage students at the primary and lower secondary levels to pursue careers in mathematics, science, and technology. Special initiatives in mathematics and science education begin at the upper secondary level.

Individual schools may organize and offer specific extracurricular programs targeting high-achieving students and/or remedial courses for lower achieving students in addition to regular school activities.

Suggested Readings

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