Finland

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Introduction

Overview of Education System

The Finnish education system is decentralized. In Finland, education is considered a fundamental right of all citizens, and the main objective of Finnish education policy is to offer all citizens equal opportunities to receive education, regardless of age, nationality, place of residence, financial situation, or mother tongue.[1]

The Finnish government determines the general objectives of basic education and the allocation of instructional time among the different subjects. The National Agency of Education, which reports to the Ministry of Education and Culture, decides on the objectives and content of instruction and records them in the national core curriculum. The latest national core curriculum was introduced at the start of the school year in 2016 for Grades 1 to 6. For Grades 7 to 9, the introduction of the new curriculum was staged in 2017, 2018, and 2019. In Finland, municipalities have a great deal of autonomy and can decide independently how to organize schooling in their area. They also decide on the use of funding and, together with schools, prepare their local curricula based on the national core curriculum.[2]

Compulsory education begins with one year of preprimary education when a child turns 6. Basic education starts at age 7 and ends at age 15. Education from preprimary to higher education is free in Finland, and municipalities are obligated to provide compulsory education. The basic education syllabus, which nearly all children complete by attending comprehensive school, spans nine years. A student who has received a leaving certificate from comprehensive school in the same year or in the year before may continue to attend optional additional education (10th grade).[3]

The upper secondary level comprises general and vocational education. Both have a three year syllabus, and education is mostly free, though students must pay for materials. General upper secondary school ends in a matriculation examination that determines eligibility for higher education studies in both universities and universities of applied sciences. Vocational education can be either based in an educational institution or apprenticeship training. In apprenticeship training, most of the learning is done through practical work tasks at a workplace. The vocational upper secondary qualification examination also gives general eligibility to further university or university of applied sciences studies.

The Finnish higher education system comprises universities and universities of applied sciences. The universities engage in both education and in research and have the right to award doctorates. The universities of applied sciences are multifield institutions of professional higher education. Universities of applied sciences engage in applied research and development.

Use and Impact of TIMSS

Finland participated in TIMSS 1999, TIMSS 2011, and TIMSS 2015, but not TIMSS 2003 or TIMSS 2007. The results of TIMSS 2011 were released when the development process for the new core curriculum (2014) for basic education was beginning. In addition to the preparation of the core curriculum, TIMSS results have been used, along with other international assessments, as a support for national budget preparation. TIMSS mathematics and science researchers have actively participated in several national meetings and symposia organized by the Finnish National Board of Education, as well as international meetings. Concurrently, several articles and reports were published exploring the strengths and weaknesses of the Finnish education system in light of the TIMSS results.

The Mathematics Curriculum in Primary and Lower Secondary Grades

According to the National Core Curriculum for Basic Education, the purpose of mathematics instruction is to support the development of students' logical, precise, and creative mathematical thinking. Teaching and learning generate a foundation for understanding of mathematical concepts and structures, develop students' ability to process information, and solve problems. Due to the cumulative nature of mathematics, the instruction progresses systematically. In addition, a concrete and functional approach is seen as essential in mathematics teaching and learning. Learning is supported using Information and Communication Technology (ICT).[4]

The National Core Curriculum for Basic Education emphasizes that students' positive attitude toward mathematics and positive self-image as learners needs to be supported. Studying mathematics is seen as a goal-oriented and persistent activity in which students take responsibility for their learning. In mathematics instruction, students should be guided to understand the usefulness of the subject in their own lives and more broadly in the society. In general, teaching and learning develop students' capacity to use and apply mathematics in a versatile manner. The Finnish Core Curriculum for Basic Education dictates mathematics contents in three periods: Grades 1 and 2; Grades 3 to 6; and Grades 7 to 9. Education providers and schools may elaborate more a detailed curriculum for themselves (e.g., contents for each semester and grade).

In the first and second grades, mathematics instruction offers diverse experiences that help create a basis for the formulation of mathematical concepts and structures. The instruction is founded on topics and problems that are familiar and of interest to students. Students are taught to express their mathematical thinking through concrete tools, speech, writing, and drawing and interpreting images. Mathematics instruction lays a strong foundation for understanding the concept of numbers and the decimal system and for learning arithmetic skills.

The core objectives of mathematics instruction in the third through sixth grades are to build students' understanding of mathematical concepts and structures, and to develop students' skills in presenting their mathematical thinking and solutions to others in different ways and with the help of different tools. In addition, solving a wide range of problems independently and in a group and comparing different solutions are essential. Students study the concepts of numbers and the decimal system and expand their understanding of them. In addition, students develop fluency in arithmetic skills. During these years, the core content of instruction includes:

- Thinking skills—Enhancing students' skills in finding similarities, differences, and regularities; comparing, classifying, and ranging objects; systematically searching for alternatives; observing causal relationships and connections in mathematics. Graphic programming environments are used for planning and executing programs.
- Numbers and operations—Developing the concept of the decimal system; diversifying students' perception of connections between numbers and the structure and divisibility of numbers; basic mental arithmetic operations; practicing addition and subtraction algorithms; concept of multiplication and multiplication tables from 6 to 9 (mastery of the 1 to 10 multiplication tables); practicing multiplication algorithms; division in cases of both quotation and partition; division by number units; properties of operations and the connection between them. Rounding up figures, calculating with approximate values and estimating the magnitude of the result; introduction to negative numbers and expanding the number area to negative integers; the concept of a fraction and basic arithmetic operations with fractions in various situations; multiplication and division with natural numbers; decimals as part of the decimal system and basic arithmetic operations with decimals; introduction to percentages and a foundation for understanding percentages, percentage values, and simple calculations with percentages; connections between fractions, decimal numbers, and percentages.
- Algebra—Observing regularities of number sequences and continuing a number sequence by following its rule; the concept of the unknown; examining equations and solving them by reasoning and experimentation.
- Geometry—Building, drawing, examining, and classifying objects and figures; rectangular prisms, round cylinders, circular cones, and pyramids; classifying plane figures into polygons and other figures and examining their properties; learning more about triangles, quadrangles, and circles; concepts of a point, line segment, straight angle, and angle; drawing, measuring, and classifying angles; symmetry in proportion to a line; noticing rotational and translational symmetries in surroundings—for example, in art; introduction to the first quarter of the system of coordinates and later all quarters; the concept of scale, which is applied to enlargements and reductions (especially with maps).
- Measuring—Measuring and paying attention to the accuracy of measurement, estimating measurement results, and verifying measurements. Measuring and calculating the circumferences and surface areas of different shapes and the volumes of rectangular

prisms. Introduction to the system of measurement and unit conversions with the most common units of measurement.

- Data Processing and Software, Statistics, and Probability—Collecting data on topics that are of interest to students. Recording and presenting data in tables and diagrams. Introduction to greatest and smallest value, average, and mode. Introduction to probability in everyday situations, concluding whether an event is impossible, possible, or certain.

The core objectives of mathematics instruction in the seventh through ninth grades are to strengthen general knowledge and ability in mathematics, and deepen students' understanding of mathematical concepts and the connections between them. Instruction guides students to mathematical modeling and problem solving and encourages discovering and using mathematics in their own lives. Mathematics instruction includes goal-oriented, precise, focused, and persistent activity. Presentations and discussions about students' solutions are desirable, and students' teamwork skills are developed. The core content of instruction during these three years includes:

- Thinking Skills and Methods—Processes that demand logical thinking, such as discovering rules and dependencies and presenting them accurately; considering and determining the number of possible alternatives; strengthening reasoning and argumentation skills; interpreting and producing mathematical notations; the basics of providing proof; determining the truth value of propositions; deepening students' algorithmic thinking; programming while learning good programming practices.
- Numbers and Operations—Basic arithmetic operations also with negative numbers; strengthening students' arithmetic skills using fractions; multiplying and dividing by fractions; expanding range of numbers to real numbers; divisibility and dividing numbers into prime factors; enhancing students' skills in performing operations on decimals; strengthening students' understanding of the difference between exact values and approximations and rounding the results of operations; confirming understanding of the concept of percentages; calculating percentages and the amount a percentage expresses of a whole; calculating a changed value, a basic value, and percentage of change and comparison; calculating exponentials using whole number exponents; the concept of a square root and using a square root in operations.
- Algebra—The concept of a variable and calculating the value of a mathematical expression; reducing exponential expressions; the concept of a polynomial and addition, subtraction, and multiplication of polynomials; forming and reducing expressions; forming and solving first-degree equations and incomplete second-degree equations; solving pairs of equations graphically and algebraically; solving first-degree inequalities; deepening students' skills in examining and forming number sequences; using proportion in solving problems.
- Functions—Correlations, both graphically and algebraically; direct and inverse proportionality; the concept of a function; drawing straight lines and parabolas in the coordinate system; the concepts of an angular coefficient and a constant term;

interpreting graphs (e.g., by examining the increase and decrease of a function); determining the null points of functions.

- Geometry—Expanding students' understanding of the concepts of points, line segments, straight lines, and angles and familiarization with the concepts of lines and rays; properties connected to lines, angles, and polygons; reinforcing students' understanding of the concepts of similarity and congruence; practicing geometric construction; learning to use the Pythagorean theorem, the converse of the Pythagorean theorem, and trigonometric functions; inscribed angles and the central angle and the Thales' theorem; calculating the perimeters and areas of polygons; calculating the area, circumference, and arc and area of a sector of a circle; examining three-dimensional figures; areas and volumes of a sphere, cylinder, and cone; reinforcing and expanding students' command of the units of measurement and the conversion of units.
- Data processing, Probability, and Statistics—Deepening students' skills in collecting, structuring, and analyzing data; ensuring that students understand the concepts of average and mode; defining frequency, relative frequency, and median; the concept of dispersion; interpreting and producing different diagrams, calculating probability.

The Science Curriculum in Primary and Lower Secondary Grades[5]

In Grades 3 to 6, the teaching and learning of environmental studies can be structured as units in which students examine the surrounding world, themselves, and their actions as members of the community. Students are guided to understand their own growth and development. Problem solving and research assignments are used to deepen students' interest in phenomena in their surroundings. Toward the end of the grade unit 3–6, they also reflect on the characteristics of different fields of knowledge.

Key content areas of environmental studies in Grades 3 to 6 are selected to support the achievement of objectives, and local concerns are taken into consideration. The following content areas are used to form learning units for each grade:

- Me as a Human Being—The structure and vital functions of humans and the different stages of human growth and development; sexual development and human reproduction in an age-appropriate manner.
- Acting in Situations and Communities of Daily Life—Students practice explaining everyday situations, phenomena, and technology using the concepts and models of different fields of knowledge. Areas include traffic, fire and electrical safety, accidents, poisonings, intoxicants, prevention of bullying, and physical and mental health, as well as administration of first aid and action in threat and risk situations.
- Exploring a Diverse World—The natural environment and human activities in Finland, the Nordic countries, Europe, and other continents; valuing the diversity of nature and cultures; global understanding.

- Exploring the Environment—Students observe abiotic and biotic nature; the built and the social environment; and the phenomena, materials, and technological applications in their surroundings. Assignments direct students to practice the different stages of conducting research. Students study weather, soil, and bedrock; the concept of force; and the growth of plants.
- Structures, Principles, and Cycles of Nature—Combustion, photosynthesis, and the hydrological cycle, changes in substances, and the law of conservation of mass; the law of conservation of energy, thermal energy, and the conversion of energy; phenomena related to sound and light; near space, seasons, variation of day and night, and the structure of the Earth; relationships between organisms, their habitats and human activities; food chains, the reproduction of animals and plants, the production and routes of food, and the commercial use of forests.
- Building a Sustainable Future—Biodiversity, climate change and its mitigation, sustainable use of natural resources, promotion of health, caring for students own cultural heritage, living in a multicultural world, and the global welfare of humankind now and in the future. A collaborative project in which students practice participation and involvement at the local or the global level.

In Grades 7 to 9, educators are tasked with guiding and supporting students during these years of intense development, to ensure that they complete their studies in the basic education syllabus and to encourage them all to continue studying.

Biology

The objective of biology education is to help students understand life and its development, increase students' awareness and knowledge of nature, and guide students to understand the operation of ecosystems, vital functions of humans, and the principles of heredity and evolution. Content areas include the following:

- Biological Research—Acquainting students with the stages of biological research through their own activity.
- Field Trips to Nature and its Surroundings—Moving responsibly in nature and the knowledge of species as well as exploring and comparing the forest and other ecosystems; fieldwork, in which students observe and evaluate the environment, its changes, and human impact on them.
- The Basic Structure and Function of an Ecosystem—The structure and function of the Finnish forest ecosystem and the impacts human activities have on it; aquatic, marsh, fell, and urban ecosystems; the ecology of different species and the interdependencies between them; the importance of biodiversity in ecosystems.
- What is Life?—The basic phenomena of life with research methods typical for biology; plants are grown as a part of teaching and learning; the structure of the biological taxonomy including the structures, vital functions, and habitats of organisms; the basics of heredity and evolution; the opportunities and challenges of biotechnology.

- The Human Being—The functions of the human body and human structure, vital functions, and regulatory systems; basics of the biological factors affecting growth, development, and health; the effect of genotype and the environment on the development of different human characteristics.
- Toward a Sustainable Future—The preservation of biodiversity; climate change, sustainable use of natural resources and changes in surroundings; ecological, social, economic, and ethical principles of using natural resources; sustainable food production and animal welfare.

Geography

The objective of geography education is to support development of the students' world view. Students are guided to follow current events in their surroundings and in the world. They learn to place world news into a geographical framework. Content areas include the following:

- The Map and the Regions of the World—The world as a whole and names of key places in Finland, Europe, and the world; the use of maps, geographical information systems, and other geomedia.
- The Current, Changing World—The latest news from different areas of the world and their locations on a map; the background and regional significance of news events; following the news combined with the learning geography.
- Basic Conditions for Life on Earth—Changes in times of day, seasons, and climate and vegetation zones; the basic conditions for life, such as clean air, water, and nutrition; occurrence and sustainable use of resources.
- Changing Landscapes and Living Environments—The special features of students' local area and landscape areas in Finland; preserving diversity in students' surroundings and planning and improving comfort and safety; the natural and cultural landscapes of different areas of the world.
- People and Cultures on Earth—Cultures, people's way of life, housing, and industries in Finland, Europe, and other parts of the world; human rights and the prerequisites for a good life.
- A Sustainable Way of Living and Sustainable Use of Natural Resources—Sustainable use of natural resources and the possibilities of bioeconomy in Finland and elsewhere in the world; lifecycles of products, personal consumer choices, and activity as responsible citizens; climate change and the loss of biodiversity; the state of the environment and possibilities for cooperation in the Baltic Sea region; the effects of globalization and questions of regional development.

Physics

The objective of physics education is to support the development of students' scientific thinking and world view. The instruction of physics helps students understand the significance of physics and technology in daily life, the living environment, and society. Teaching and learning enhance

students' ability to discuss topics and phenomena of physics and technology. Content areas include the following:

- Scientific Research—Relevant stages of the research process; reflecting on a problem or a phenomenon; planning and setting up experiments, making observations, and measuring; compiling and processing results and evaluating and presenting results; utilizing ICT at different stages of research.
- Physics in students' Daily Life and Living Environment—Forms of electromagnetic and particle radiation; heat on a qualitative level.
- Physics in Society—Energy production and sustainable use of energy resources; education paths and professions that require physics knowledge.
- Physics Shaping the Worldview—Nature of physics as a discipline; the law of conservation of energy and the structures and dimensions of the universe.
- Interaction and Motion—Interactions between two objects; forces affecting one object and the impact of these forces on an object's motion; models for constant and changing motion; mechanical work and power connected to energy.
- Electricity—Connection between voltage and electric current as the basis for examining an electric circuit; electrical safety at home and the use and generation of electricity; electrical charge and magnetism; various phenomena of electric circuits.

Chemistry

The objective of chemistry education is to support the development of students' scientific thinking and world view. Chemistry instruction helps students understand the significance of chemistry and its applications in daily life, the living environment, the society, and technology. It supports students' ability to make choices and to use their knowledge and skills in different life situations. Students learn that chemistry has an important role in building a sustainable future: chemistry is needed to develop new technological solutions and secure the well-being of humans and the environment. Students are guided to take responsibility for their environment. Content areas include the following:

- Scientific Research—Relevant stages of the research process; reflecting on a problem or a phenomenon, planning, setting up an experiment, making observations, compiling and processing results, and evaluating and presenting results; utilizing ICT at different stages of research.
- Chemistry in Students' Daily Life and Living Environment—Local environments and students' surroundings; chemicals and fire safety at home; changes in states of matter.
- Chemistry in Society—Sustainable use of natural resources, and the idea of product life cycle; education paths and professions that require chemistry knowledge.
- Chemistry Shaping the World View—The nature of chemistry as a discipline, the laws of conservation of mass and energy, and the dimensions of nature.

- Properties and Structure of Substances—Properties of mixtures and pure substances, such as water solubility and fat solubility; characteristics of chemical elements; the atomic structure of matter, the structure of an atom, and the periodic table; carbon and its compounds; nutrients; some organic compound groups.
- Properties and Changes in Substances—Changes of energy and substances in chemical reactions; reaction rate and factors that influence it; the carbon cycle and its significance for life; concentration and acidity in connection to everyday examples; chemical symbols and simple reaction equations.

Health

In Grades 1 to 6, health education is taught as a part of environmental studies. In Grades 7 to 9, health education advances and expands the themes studied in the lower grades according to the students' ages. The instruction strives for more accurate use of concepts specific to the field of knowledge and reinforces competence related to age-appropriate critical thinking, self-awareness, and ethical reflection. Health literacy helps students perceive the extensiveness of health and enables them to make healthy choices and decisions. Content areas include the following:

- Growth and Development Supporting Health—Building of identity, self-image, and self-awareness; sexual development; the significance of care, family and friends, mental well-being, and self-appreciation; safety skills associated with growth and development.
- Factors Supporting and Harming Health and Prevention of Illnesses—Daily rhythm, sleep, nutrition and exercise; sexuality, sexual health, and sexual development.
- Health, Communities, Society, and Culture—Sustainable way of life, social sustainability, and responsible consumption; health impacts of the living environment; key approaches to the promotion of health and prevention of illness; health services; civic activity; and health risks in the environment.

Professional Development Requirements and Programs

Teachers' collective agreements on working conditions regulate their obligation to participate in planning and professional development for three days during the school year, for six hours each day.[6] Employers decide which training programs and forms of education are accepted as professional development training conforming to the collective agreement. However, teachers have been given greater responsibility for developing their professional skills and expertise. More and more attention is being paid to self-motivated continuing education and training.[7]

The Finnish National Agency of Education (*EDUFI*) is responsible for funding, monitoring, and promoting teacher professional development, usually focusing on topics relevant to national education policy. Education providers can apply for funding from the National Agency for Education on a yearly basis.[8]

Teacher employers, such as municipalities, typically are responsible for organizing and supporting financially their staff's professional development, including in-service training.

Regional authorities, *EDUFI*, and universities and universities of applied sciences, as well as, commercial companies provide in-service training and professional development programs. LUMA Centre Finland, which is a network of Finnish universities, promotes science and mathematics education and offers support for teachers' professional development. Other ongoing professional development programs include LUMATIKKA and JoMa, which aim to develop teachers' mathematical competencies and pedagogical skills.

Monitoring Student Progress in Mathematics and Science

The Finnish National Agency of Education has been responsible for developing education, and thus has conducted national assessments of learning outcomes. Since 2014, The Finnish Education Evaluation Centre (*FINEEC*), as an independent expert organization, has been responsible for conducting and developing national evaluations of education. National assessments are sample-based and focus on the central content of the national curriculum, mainly at the end of basic education. Since 1998, *EDUFI/FINEEC* has implemented a national assessment of mathematics six times for Grade 9 (in 1998, 2002, 2004, 2011, 2012 and 2015) and twice for Grade 6 (in 2000 and 2007). During this same period, two national assessments of natural sciences have been implemented for Grade 9 (in 1998 and 2011). These national assessments provide schools and teachers with regular updates about the knowledge and skills of their students in relation to other schools and national objectives of instruction. They do not affect students' grades or marks.

Under the Basic Education Act,[9] the goal of student assessment is to guide and encourage learning and develop students' capability for self-assessment. Students' learning, work, and behavior is variously assessed. These tasks are the point of departure for developing the assessment culture in basic education. The emphasis is on assessment that promotes learning.

Cooperation between home and school is part of a good assessment culture. The objectives of schoolwork and the school's assessment practices are discussed with each guardian. Both a student and the student's guardian are informed at sufficiently frequent intervals of the student's progress, working skills, and behavior. The student and guardian are entitled to be informed of assessment criteria and their application to the student's assessment. Joint discussions between the teacher, student, and guardian promote mutual trust and communicate information about the student's situation. Cooperation with guardians of students requiring special support is particularly vital.

Information obtained through assessment helps teachers to adapt their instruction to students' needs. It lays the foundation for the differentiation of instruction and helps to identify students' potential needs for support. Education providers monitor the implementation of assessment principles in schools and support the development of assessment.[10]

Teachers are responsible for student assessments in their classrooms and may decide on the methods of assessment, which typically include teacher-made examinations, examinations based on textbooks, and continuous observation of student progress.

Special Initiatives in Mathematics and Science Education

LUMA Centre Finland, established in 2013, shares the national concern over the level of competence in mathematics, science, and technology, in general, and over the insufficient amount of professionals in these fields. The aim of the LUMA Centre Finland is to inspire and motivate children and youth into mathematics, science, and technology through the latest methods and activities of science and technology education. The aim is also to support the lifelong learning of teachers working on levels of education from early childhood to universities and strengthen the development of research-based teaching.[11]

Currently, LUMA Centre Finland has four ongoing projects:[12]

- LUMATIKKA-program (2018–2022) implements postgraduate education (15 ECTS) program for mathematics teachers working on levels of education from early childhood to upper secondary education.
- StarT-program (2016) develops and offers support to learning communities to implement multidisciplinary learning modules and theme-based studies in compliance with national core curricula.
- ZAU-program (2018–2020) offers opportunities for elementary schools, among others, to organize phenomenon-based clubs. These clubs are intended especially for girls, and their aim is to inspire interest in mathematics, science, and technology.
- LUMA2020 (2019–2020) develops science and mathematics teaching and learning in collaboration with daycare centers, schools, businesses, and various organizations.

The core curriculum for basic education states that the selection of working methods is guided by differentiation of instruction. In mathematics, each student has the opportunity for instruction in the most central content areas of previous grades if the student lacks sufficient command of them. Anticipatory support is also given for learning new content. Talented students are supported by through alternative working approaches and by enriching the learning content. In science, the differentiation to meet individual needs may be supported by an inquiry-based working method and exercises completed at various levels of thinking, as well as in collaborative research assignments that require students to act in different roles and progress individually to different levels of thinking.[4]

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