Austria

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Introduction

Overview of Education System

Austria is a federal parliamentary republic consisting of nine provinces (*Bundesländer*), each with its own provincial government. German is the official language and the language of instruction used in almost all Austrian schools. In some regions, schools offer instruction in the minority languages Slovenian, Croatian, and Hungarian, with German as an additional language of instruction. Private schools may offer other languages of instruction or bilingual instruction.

The school system in Austria is highly centralized. The Federal Ministry of Education, Science, and Research has overall responsibility for primary, secondary, and tertiary education as well as partial responsibility for adult education. Kindergartens and crèches are mainly the responsibility of the provinces (*Bundesländer*). Education legislation is almost entirely a federal responsibility, including duration and entry age for compulsory education, duration and organization of school instruction, and formulation and approbation of curricula, textbooks, and other school material. Private schools may deviate from the mandated structure or contents but may have to prove the equivalency of their education approach.

The responsibility for implementation is divided between the federation (Bund) and the provinces. The provinces have responsibility for providing preprimary and public sector compulsory education as well as part-time vocational schools for apprentices. They support local communities in establishing and maintaining these institutions via school construction funds and provision of support personnel. The federation is in charge of establishing, maintaining, and staffing federal schools, which comprise academic secondary schools as well as upper secondary VET schools and colleges.

Preprimary education may be offered in *crèches* (up to age 3), kindergartens (from 3 years until school entry and in mixed-age facilities), or children's groups (mostly mixed-age), or by private childminders. Since 2009, all children at age 5 (i.e., in the year before starting primary school) are required to attend one year of kindergarten. Children reaching school age who are considered insufficiently mature for regular school must attend a preschool class at school for one year.

Compulsory schooling lasts nine years, starting at age 6 with attendance in primary school (*Grundschule* or *Volksschule*,[a] International Standard Classification of Education [ISCED] 1). Primary schools comprise Primary Level 1 (*Grundstufe I*, Grades 1 and 2) and Primary Level 2 (*Grundstufe II*, Grades 3 and 4).

Lower secondary education (ISCED 2) starts in Grade 5 and comprises four grades. It marks the beginning of academic tracking by division of schools into general secondary school (*Mittelschule*) and academic secondary school lower level (*Allgemeinbildende höhere Schule Unterstufe*). In recent years, Austria has reformed lower secondary education to enhance the permeability of the education system and to mitigate some undesirable effects of early tracking. The reforms included school organization, teacher education, education standards for all students, and reshaping of general secondary schools.

Upper secondary education (Grades 9 to 12) in Austria is highly diverse, spanning from one-year courses (prevocational school, ISCED 3G), to vocational schools for apprentices (3 to 4 years, ISCED 3V) or vocational schools for intermediate vocational training or health professions (2 to 4 years, mainly 3 years, ISCED 3V or 4V), to schools offering a secondary school leaving certificate (Matura) for admission to higher education. These institutions are either upper secondary academic schools (ISCED 3G) or colleges for higher vocational education (Grades 9 to 11, ISCED 3V; Grades 12 and 13, ISCED 5V).

Tertiary education institutions comprise universities, universities of applied sciences (*Fachhochschulen*), University Colleges of Teacher Education (*Pädagogische Hochschulen*), and schools for advanced vocational or professional education (*Werkmeister-, Meister- und Bauhandwerkerschulen*, ISCED 5V).[1]

Use and Impact of TIMSS

Austria first participated in TIMSS in 1995. While primary school students showed high achievement levels in both mathematics and science, students in lower secondary and specifically in upper secondary schools achieved below expectations. As a result, education initiatives were started to analyze the results and suggest improvements.[2] Since then, Austria participated in TIMSS 2007, 2011, and 2019. So far, the main use of TIMSS data has focused on two topics: first, international comparison and, specifically, comparison with neighboring countries and members of the European Union, and second, review of trends over time. The results of TIMSS 1995 also triggered debates about the quality of the Austrian education system and were used as evidence of the need for reforms. Before 2012, there was no national assessment of achievement in Austria; therefore, international study data such as results from TIMSS were also used for system monitoring. Starting in 2012, the assessment of national educational standards has been implemented in Grades 4 and 8. After 2019, additional national assessments in Grades 3 and 7 were decreed; implementation will be finalized in 2023. However, because the national assessments

[a] In very few locations, *Volksschulen* offer eight grades, spanning ISCED 1 and 2.

focus on mathematics and reading in Grades 3 and 4—and not science—TIMSS remains the only source of information regarding science achievement at the end of primary education in Austria.

Mathematics Curriculum in Primary and Lower Secondary Grades

Currently, the curriculum for mathematics is undergoing revisions. This section focuses on the curriculum at the time of the TIMSS 2019 data collection (in place since 2003).

Mathematics Curriculum in Primary Grades

The curriculum for primary education (Grades 1 to 4)[3] consists of the following parts: general education targets, general rules including instructional and education principles; general didactic principles, subject tables and suggested weekly hours per subject,[b] educational and instructional tasks, and teaching content and didactic principles for the different subjects. In terms of teaching content, the curriculum provides a framework laying out the general overarching aims and states subjects within those content areas intended to meet the general aims. Thus, the curriculum is the basis for teachers to plan and implement lessons autonomously.

The mathematics curriculum is divided into the following topics:

- Structure of Whole Numbers: In this domain, students should develop basic abilities in mathematics and be able to establish a concept of whole numbers. In Grades 1 and 2, students use numbers up to 100. In Grades 3 to 4, students' understanding of numbers should be expanded and deepened; the number spectrum should reach 1,000 in Grade 3 and 1 million in Grade 4. Students in Grade 4 should also be able to read and interpret graphical representations and tables.
- Arithmetic Operations: In Grades 1 and 2, topics range from learning the concepts underlying the operations to carrying out all four arithmetic operations (addition, subtraction, division, and multiplication). Students should be able to use operations to solve real-life problems and to match mathematical operations to everyday situations as well as finding everyday situations to demonstrate mathematical operations. In Grades 3 and 4, the use of arithmetic operations intensifies, and the number spectrum becomes progressively larger. Students should understand the role of zero in operations and should be able to solve simple equations featuring placeholders. Students should be able to use mathematical representations to demonstrate and solve problems, and to create number games, mathematical puzzles, or strategy games.
- At Primary Level 2, there is an additional topic, fractions, which follows arithmetic operations. In Grade 4, fractions are introduced with 2, 4, or 8 as a denominator.
- Quantities/Magnitude: Students should understand comparisons and formulations of relationships; be introduced to units of measurement (arbitrary units and normalized units, such as length, weight, time, money, and basics of volume); and apply units in

[b] Schools may increase or decrease the suggested hours per week by a maximum of two hours per week, but they must not cancel a mandatory subject.

different situations. In Grades 1 and 2, students develop the concept of quantities/magnitude and learn to apply units of measurement. Grades 3 to 4 focus on estimation as well as measuring, comparing, and transforming units of measurement. Operations with money using decimals include adding and subtracting, introducing the concept of decimals.

- Geometry: Main targets for Grades 1 and 2 are observing, ordering, and structuring of spatial relationships and shapes; enhancing the ability to orientate; and establishing the use of technical aids for drawing and solving real life problems using geometry. Students should be able to investigate and describe simple geometric figures and solve problems featuring spatial aspects or geometric figures. Grades 3 and 4 focus on identifying and classifying geometric figures, measuring objects, and using drawing instruments or equipment. Students also learn how to calculate the perimeter and area of rectangles and squares.

Complementing the curriculum, the national education standards for mathematics describe desired learning outcomes in Grade 4. A competence model, featuring four content dimensions and four general mathematical competency dimensions, has been established to facilitate the teaching process as well as the assessment and evaluation of learning progress.

Mathematics Curriculum in Lower Secondary Grades

In Grades 5 to 8 (lower secondary schools, ISCED 2), two versions of the mathematics and science subject (physics, Earth science, biology, and chemistry) curriculum exist: one version for general secondary school (*Mittelschule*)[4] and one for academic secondary school lower level (*Allgemeinbildende höhere Schule Unterstufe*).[5] In both school types, a minimum of two-thirds of the instructional time per subject has to be devoted to "core" topics; up to one-third may be chosen from "extended" topics. The topics are the same for general and academic secondary school. The curriculum for general secondary school lists a distinction in mathematics in Grades 7 and 8 between "basic" and "extended" educational content, where extended content is meant to foster more complex argumentation; the topics are the same for both the basic and the extended version. To support the students in general secondary schools in mastering extended content, the federal ministry provides additional teacher resources of up to six hours per week for mathematics, German, and the first foreign language.

Contents of the mathematics curriculum in Grades 5 to 8 are grouped by grade and content.

- Numbers and Units: Students should extend their ability to use whole numbers and gain deeper familiarity with decimals, fractions, and the rules for the order of arithmetic operations. Students should be fluent in mental arithmetic and able to use electronic devices for mathematical operations. Percentages and their use are introduced, followed by rational numbers, their representation, and coordinate systems. Students should be able to understand and reason why arithmetical situations cannot always be solved with rational numbers.

- Variables: Students should be able to describe generic situations with variables and formulate and solve equations. From Grade 6 on, students should be able to solve linear equations with one unknown term, transform formulas, and use formulas and equations for real life problems. At the end of Grade 8, students should be able to solve linear equations with two variables and understand and prove functional dependencies.
- Geometric Figures and Shapes: Students should be able to recognize and describe geometric figures and shapes and their properties, starting with calculating the perimeter and area of a rectangle as well as the volume and surface area of a cube and rectangular shape, and work with angles and symmetric figures. In Grade 6, working with geometric figures extends to include triangles, quadrilaterals, and regular polygons and the volume of prisms. In Grade 7, new content comprises formulas to calculate the area of triangles and quadrilaterals, the Pythagorean theorem, and the scaling up and down of figures. In Grade 8, reasoning of the Pythagorean theorem follows, along with calculations and use of circumference and area of circles, and surface areas and volumes of pyramids, cylinders, cones, and spheres.
- Models and Statistics: Students should be able to use tables and graphical displays to record data, compare models with real life situations, and understand the purpose of models. In Grade 6, characteristics of direct and indirect proportions are introduced as well as relative frequencies and their graphical representations. Students should be able to spot manipulations. In Grade 7, the focus is on increasing and decreasing processes, such as interest loans and investigating and displaying functional dependencies. In Grade 8, students should be able to analyze data and present results of statistics such as mean, median, quartiles, and relative frequencies in adequate graphs and scatter plots.

Science Curriculum in Primary and Lower Secondary Grades

As in mathematics, the curricula for science are currently undergoing revisions. This section focuses on the curricula in place at the time of the TIMSS 2019 data collection (in place since 2011).

Science instruction in primary school is included in the integrative subject *Sachunterricht,* which is divided into the following learning areas: Community, Nature, Space, Time, Economics, and Technology. The curriculum in the primary grades includes all of these learning areas, describing the subject matter combined for Primary Level 1 (*Grundstufe I,* Grades 1 and 2) and Primary Level 2 (*Grundstufe II,* Grades 3 and 4). The main difference from the TIMSS framework in the Austrian primary school curriculum is the absence of the topic area Earth in the Solar System, which in TIMSS is anchored in the content domain Earth Science.

In Austria, the most expansive learning areas are Nature and Technology. Nature focuses on understanding the environment, as well as knowledge of the human body. In Grades 1 and 2, themes are introduced with simple examples. There is also an emphasis on the nature in close vicinity to the students. Grades 3 and 4 then focus on emphasizing further understanding and application. The main topics in Nature are:

- Life processes and biological systems, focusing on introducing scientific working methods and knowledge about life cycles and ecosystems
- Diversity in nature, such as characteristics, morphology, and habitats of certain plants and animals
- Responsible behavior toward nature—e.g., humans' relationship with nature, as well as knowledge about ecological effects of human activity and topics of responsible behavior to protect the environment
- The human body and health, learning about senses, organs, a healthy lifestyle, basic first aid, hygiene, and sexuality

Technology, in conjunction with the school subject Handicrafts, focuses on technical realities in the students' environment, natural forces and their effects, and materials and their transformation. In each of the corresponding topics in that learning area, students are introduced to specific scientific working methods. In Grades 1 and 2, the subtopic Technical Facts in the students' environment also relates to mechanical objects, such as tools, wheels, handles, and switches. Grades 3 and 4 extend this knowledge to the indirect environment. Students also learn about handling objects and specific operational methods through examining, measuring, and experimenting with objects. Specifically, students explore objects by viewing and measuring and conduct their first experiments. Water is an omnipresent significant theme throughout primary education, as is responsible use of technical equipment and precautionary measures to avoid accidents. The main topics in Technology are:

- Learning about technical conditions in the students' environment; learning about equipment and acting responsibly with it
- Forces of nature and their effects, such as natural effects like magnetic force, thermodynamic effects, weather phenomena, and gravity
- Materials, changes in materials, responsible handling of materials and scientific working methods

Regarding lower secondary education (Grades 5 to 8), the Austrian school system is divided into two main branches: the general secondary school and the lower level academic secondary school (see above for details). However, the science curriculum is the same, with at most only minor differences between branches.

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

Science is divided into several subjects in lower secondary schools. From fifth to eighth grade, students are taught Biology and Environmental Education as well as Geography and Economics,

including geological topics contained in TIMSS. Students have physics classes in Grades 6 to 8, and in Grade 8, they also have chemistry. School autonomy enables each school to adjust these regulations according to their school profile; however, cancellation of a subject is not allowed.

Biology and Environmental Education mainly covers Human Beings and Health, Animals and Plants, and Ecology and the Environment. Topics include the following:

- Human Beings and Health: An overview of the structure and functioning of the human body, organs, movement and health, sexuality, and the effects of micro-organisms and the ecosystem on human health
- Animals and Plants: Structure and function of local animals and plants, specifically vertebrates and spermatophytes (Grade 5); invertebrates, spermatophytes, cryptogams, fungi, micro-organisms, and the cell as the basic unit of living things (Grade 6); useful plants and production animals, and evolution (Grade 7); the roles of organisms in ecology, specifically in urban ecology, and heredity and possible uses (e.g., in genetic engineering) (Grade 8)
- Ecology and the Environment: Basic ecological terms; positive and negative outcomes of human acts; environmental problems and protection and conservation (Grade 5); forest ecosystems, national water ecosystems, and environmental issues (Grade 6); land ecosystems and agricultural ecosystems focusing on soil (Grade 7); ecosystems, ecological niches, cycles of matter (Grade 8).

Geography and Economics mainly covers the diversity of human life and economies on Earth. Using globes and maps, students learn about the lives and economies of people in different areas, reactions to natural disasters, use of natural resources and energy, economic systems and climatic conditions, living in urban communities, production of goods in industrial and commercial enterprises, fields of services, and the Earth as a living and economic area. There is a strong focus on economic topics not covered in TIMSS. In Grades 5 and 6, the subject mainly covers the social, economic, and ecological boundaries of our world, which also include climate and the impact on ecosystems, focusing on Austria and Europe. In Grade 7, the topics cover the differences in natural and human-engineered environments, working environments, occupational and professional facts, unemployment, and financial competencies. Grade 8 is dedicated to globalization, political and economic systems, and urban living.

Physics (taught in Grades 6 to 8) gives students a general understanding of the physical thought model (real world - model - model characteristics - real world) and covers the following topics:

- Grade 6: Physical thinking and the difference to nonphysical thinking; facts hindering or supporting movement; the particle model and its effects on solid properties; heat phenomena; sound; swimming, floating and sinking; and the principles of aerodynamics
- Grade 7: Thermal activity; heat conduction, flow and radiation; understanding of global or local weather; electrical procedures and electrical circuits; voltage; direct and alternating current; amperage; and resistance

- Grade 8: Production, transport and consumption of electrical energy; relationship between electrical and magnetic energy; magnets; dangers of electrical current; formation and dispersion of light; natural colors; functioning of optical devices; forces; the movement of objects on Earth and in space; procedures in the atomic nucleus; causes of radioactivity, radioactive decay; basics of nuclear fusion and fission.

Chemistry is taught in most schools only in Grade 8 and includes the following topics:

- Classification and characteristics of materials, different materials and separating matter, particle and atom structure, the periodic table, chemical bonding as prerequisite for the diversity of matter, basics of structures of inorganic and organic matter
- Basic patterns of chemical reactions, including attributes of acids, bases, and salts and reaction of acids and bases; oxidation and reduction; connection between material and energetic changes through segmentation and composition of bonds
- Sources of raw materials and their responsible use—specifically, air, water, and soil and their fundamental importance for life; waste, disposal, and recycling
- Biochemistry and health education; food, medication, and drugs; dangers in handling everyday chemicals and precautions

Professional Development Requirements and Programs

In-service training is provided by university colleges of teacher education. Every teacher has the duty to attend professional development activities; however, topics and courses are not mandated. Teachers may choose from a variety of courses.

Monitoring Student Progress in Mathematics and Science

In Austria, national standardized tests have existed only since 2012 for mathematics and German for Grades 4 and 8, as well as for English as the first foreign language for Grade 8. However, the results were mainly used for monitoring at the school, class, and system levels and only marginally for reporting of individual students' competencies.[6] This monitoring system is currently under revision. Student achievement in mathematics, German (reading), and English (receptive skills) will be assessed nationally in Grades 3, 4, 7, and 8, starting in 2021. The test will be administered by classroom or subject teachers and therefore results will be available almost immediately (except for open ended formats requiring manual scoring). The focus lies on the formative aspect of testing—that is, teachers' information about student competencies and student information about their achievement level in comparison to other students. This change should foster evidence-based development of instruction and the deeper understanding of individual competence levels as well as students' progress in the subjects. System monitoring will remain with standardized reports for school authorities, federal and national governments, and public reports. Science achievement is not part of the national standardized assessments but is monitored by teachers as part of instruction. In science, work is often hands-on, and progress may also be monitored by the development of students' work pieces.

In addition, teachers monitor student progress in class in a variety of ways, including observation of in-class participation, homework, results of tests and examinations, and other ways students demonstrate their competencies.

Special Initiatives in Mathematics and Science Education

Mathematics and Science are considered key competencies for mastering the challenges of digitalization as well as those of climate change.[7] Therefore, several initiatives fostering the interest and competencies of students in mathematics, science, and technology (*MINT* subjects) have been started in recent years in addition to established initiatives, such as *IMST*.[8] A joint initiative of the Ministry of Education, Science, and Research, the university college of teacher education at the University of Vienna, the Federation of Austrian Industries, and a network of private business partners is the *MINT-Gütesiegel* (MINT label of excellence). Schools offering a focus on *MINT* subjects or innovative teaching and learning methods in these subjects may apply for this seal. Institutions may use the seal for three years, after which time they may reapply for it. The seal is awarded to institutions of all levels of education, from preprimary to upper secondary schools; the prerequisites depend on the education level. In addition, many university colleges of teacher education offer specific courses, both for preservice as well as in-service training. Courses may also target audiences beyond teachers, mostly in cooperation or networking with regional governments, universities, and other government, nongovernment, or private partners. Also, a wide range of special initiatives of shorter duration is available, such as a yearly award for media literacy; yearly competitions in mathematics, physics, chemistry, and informatics as preparations for the international Olympiads; as well as projects featuring mathematics, science, or informatics topics.

In Austria, the rather large gaps in mathematics and science competencies between student subgroups are an area of concern. Several studies, beginning with TIMSS 1995, showed gender differences in mathematics, science, and technology. The Programme for International Student Assessment (PISA) shows that girls tend to show lower competencies in science and mathematics and are less interested in learning mathematics and science.[9,10] National assessments in mathematics also show a large gender gap beginning in Grade 4.[11,12] Therefore, a particularly important aspect is promoting *MINT* subjects among girls and women. Most *MINT* initiatives encourage girls to enhance their interest in these subjects and to plan a career in *MINT* areas, and seek to foster science careers among women by presenting role models and grants for young female researchers.

Suggested Readings

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