# Denmark

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## Introduction

### Overview of Education System

The main Danish public school system is known as *folkeskolen*, which is a comprehensive system covering both primary and lower secondary education.[1] The management of public schools in Denmark is regulated by *Folkeskoleloven* (the Folkeskole Act).[2] Public schools are administered at the municipal level, with each of the 98 municipalities in Denmark having the authority to make decisions on matters such as the allocation of financial resources and the organizational structure of schools within the municipality.

The national curriculum is established through so-called Common Objectives (elaborated below), and each municipality is responsible for ensuring that its schools align with these objectives. Each school has its own school board, primarily composed of parents, but also including students, teachers, school management, and, if desired by the school board, a representative from the municipality. While the municipality can delegate decision-making authority to the school board, it has an obligation to ensure that each school complies with relevant legal requirements. The school board operates within the objectives and framework defined by the municipality and can establish general principles governing all aspects of the school's activities except matters related to individual staff or students. A school may consist of multiple geographically separate departments that share a school principal and a school board. The language of instruction in Danish public schools is Danish. Some private schools, including German minority schools and some international schools, are allowed to teach in languages other than Danish.

Since the establishment of compulsory education in Denmark in 1814,[3] private schools have been an integral part of the country's education system, with the possibilities of attending private schools and for homeschooling regulated by *Folkeskoleloven*. The regulation of private schools falls under the jurisdiction of the Private and Independent Schools Act.[4] According to this legislation, private schools must demonstrate financial self-sufficiency as self-governing institutions. They are also required to articulate a set of core values and make these values publicly accessible. Private schools are expected to deliver education standards that align with those set by the Folkeskole Act while maintaining their unique core values and operating within the parameters outlined by both the Folkeskole Act and the Private and Independent Schools

Act. The Ministry of Children and Education monitors private schools to ensure that they comply with these requirements and has the authority to withdraw public funding from schools found in violation.

Preschool, primary education, and lower secondary education is compulsory in Denmark, with public schooling provided free of charge. However, school enrollment is not mandatory, meaning that children can be taught at home if the education provided meets the same standards as those available at public schools, although this option is rarely utilized.

The system of primary and lower secondary education in Denmark comprises three main levels: preschool class (referred to as Grade 0 in Denmark, equivalent to a preschool or kindergarten class), primary (Grades 1 to 6, aligning with International Standard Classification of Education [ISCED] Level 1), and lower secondary (Grades 7 to 10, aligning with ISCED Level 2).[5] While lower secondary education predominantly spans Grades 7 to 9, the Danish system also includes an elective Grade 10 within the framework of primary and lower secondary education. At the beginning of academic year 2022–2023, the total student population in primary and lower secondary education in Denmark was approximately 682,000, which included roughly 39,300 students in the optional Grade 10. In academic year 2022–2023, the student distribution in Grades 0 to 9 was as follows: 75% were enrolled in public schools; 18% attended private and independent schools; 5% were registered at boarding schools/continuation schools; and 2% received education in alternative settings, including special education schools, treatment centers, or through homeschooling.[6]

Since August 2009, compulsory education in Denmark has started with Grade 0 (preschool class). The academic year commences in August, with children usually entering Grade 0 in the calendar year during which they reach the age of 6,[7] although it is possible to remain in kindergarten for an additional year under special circumstances.[8] Following the completion of Grade 0, compulsory education continues for an additional 9 years. Upon successfully finishing Grade 9 or the optional Grade 10, students may choose from a range of youth education programs classified at ISCED Level 3. These programs can be academically focused, vocationally oriented, or a combination of both. The academically focused track spans 3 years, covering Grades 10 to 12, and qualifies students for admission to bachelor's programs at universities or professional bachelor's programs at university colleges. The vocationally oriented tracks vary in duration, equipping students with the qualifications needed to pursue careers in specific professional fields. In some instances, these vocational programs also qualify for entry to further education in the form of professional bachelor's programs and academy profession programs.[9]

## Use and Impact of TIMSS

Since 2007, Denmark has participated in every cycle of TIMSS for Grade 4. Prior to that, Denmark participated with Grade 8 students in 1995. All cycles have been conducted by a research team at the Danish School of Education, Aarhus University, and since 2011, have been partly financed by the Danish Ministry of Children and Education. Based on each cycle,

national reports are published (in Danish) that present the main findings from Denmark.[10,11,12,13] The Ministry of Children and Education uses these reports as one of many information sources to inform policy decisions. Secondary analyses of Danish results have been relatively sparse, and until the 2019 cycle, TIMSS has had considerably less influence on Danish mathematics and science teaching than the 1994 International Association for the Evaluation of Educational Achievement (IEA) reading literacy study and the subsequent PIRLS studies have had on Danish literacy teaching.[14,15] In 2020, when Danish results from TIMSS 2019 were released, a major public and political debate began due to a significant decrease in fourth-grade students' mathematics proficiency in Denmark. In many contexts, good mathematical skills are considered absolutely vital, both for the individual citizen and for society. Therefore, in the autumn of 2021, the Danish government established a mathematics expert group, which was tasked with identifying the most significant challenges and developing a catalogue of proposed solutions to the challenges identified by TIMSS 2019 and other research. TIMSS is explicitly referenced in the rationale for establishing this expert group and is considered a potential source of evidence for their work.

## The Mathematics Curriculum in Primary and Lower Secondary Grades

In the Danish mathematics curriculum for primary and lower secondary grades, students are expected to develop mathematical skills and knowledge and be able to apply them in everyday life in relation to further education, work, and community demands. They are expected to recognize the role of mathematics in historical, cultural, and social contexts and to take a critical stance regarding how mathematics is applied in order to effectively fulfill their civic and democratic responsibilities. Students' learning should be based on both independent and cooperative experiences of how mathematics requires and promotes creativity, and how it involves instruments for problem-solving, argumentation, and communication.[16] The Common Objectives define the overall learning objectives for mathematics at the end of Grades 3, 6, and 9. These objectives are divided into four fields of competence with corresponding competence goals (see Exhibit 1).

**Exhibit 1: Fields of Competence and Competence Goals, Mathematics**

| Field of Competence | After Grade 3 | After Grade 6 | After Grade 9 |
|---|---|---|---|
| Mathematical Qualifications | The student is able to apply mathematics in real-world situations. | The student is able to apply mathematics with comprehensive understanding in complex situations. | The student is able to apply mathematics with judgment in complex situations. |
| Numbers and Algebra | The student is able to develop methods of calculation with natural numbers. | The student is able to apply rational numbers and variables in descriptions and calculations. | The student is able to apply real numbers and algebraic expressions in mathematical studies. |
| Geometry and Measurement | The student is able to apply geometric concepts and measurements. | The student is able to apply geometric methods and calculate simple measurements. | The student is able to explain geometric contexts and calculate measurements. |
| Statistics and Probability | The student is able to perform simple statistical surveys and express intuitive chance sizes. | The student is able to perform statistical surveys and determine statistical probabilities. | The student is able to evaluate statistical surveys and apply probability. |

In each field of competence, there are two to six domains of skills and knowledge, as shown in Exhibit 2. Within each of these domains, there are additional subdivisions in the form of two to six specific skill and knowledge objectives, which become more advanced as students progress through the grade levels. While the domains are outlined in this chapter, the specific skill and knowledge objectives are not included due to their extensiveness. However, as an example, within the Numbers and Algebra field of competence and the Methods of Calculation domain of skills and knowledge, a specific skill and knowledge objective for Grade 6 students is as follows: “The student has knowledge of strategies for calculations with percentages.” In 2019, the skill and knowledge objectives were changed from binding to indicative, although the overall objectives and domains remained the same.[17] Because the competence goals for Grade 6 are required national goals, they also serve as the guidelines for Grade 4 mathematics instruction. Within the framework of the Common Objectives, students may encounter specific skills, such as division, at different points of time within the grade range addressed by the Common Objectives, depending on decisions about the local curriculum made by the municipality, the school board, or the teacher. In practice, the order in which the student encounters specific skills and knowledge is often determined by the order in which the textbook presents different content.

**Exhibit 2: Domains of Skills and Knowledge, Mathematics**

| Field of Competence | Domains of Skills and Knowledge | Grade 3 | Grade 6 | Grade 9 |
|---|---|---|---|---|
| Mathematical Qualifications | Problem-Solving | X | X | X |
| | Modeling | X | X | X |
| | Reasoning and Thinking | X | X | X |
| | Representation and Treatment of Symbols | X | X | X |
| | Communication | X | X | X |
| | Mathematical Tools | X | X | X |
| Numbers and Algebra | Numbers | X | X | X |
| | Methods of Calculation | X | X | X |
| | Algebra | X | X | |
| | Equations | | | X |
| | Formulas and Algebraic Expressions | | | X |
| | Functions | | | X |
| Geometry and Measurement | Geometric Properties and Relationships | X | X | X |
| | Geometric Drawing | X | X | X |
| | Location and Movement in the Coordinate Plane | X | X | X |
| | Measurement | X | X | X |
| Statistics and Probability | Statistics | X | X | X |
| | Probability | X | X | X |

Given that not all students are expected to fulfill all aspects of the Common Objectives, specific skill and knowledge objectives are emphasized as priority points. In Danish, these are referred to as *Opmærksomhedspunkter*, which can be directly translated as "points for attention" in English. These priority points are regarded as the most crucial components within the Common Objectives, and every student is expected to attain proficiency in them.[18,19]

The current national mathematics policies were first introduced in the 2015 edition of the Common Objectives and were later revised in 2019.[20] More recently, there has been a political emphasis on streamlining the curriculum, with a goal of reducing 9 out of 10 skill and knowledge objectives. This is described in the government's program titled *Prepared for the Future II: Freedom and Depth – A Quality Program for Primary and Lower Secondary Education*, published in October 2023.[21] Note that the aim of reducing the number of objectives applies to all subjects and not just mathematics.

## The Science Curriculum in Primary and Lower Secondary Grades

In primary school (Grades 1 to 6), science is taught in the integrated subject nature and technology (*natur/teknologi*). This provides a foundation for science teaching in Grades 7 to 9, which is divided across three separate subjects: geography, biology, and physics/chemistry.[22]

The overall aim of the subject nature and technology is for students to develop competencies within the subject and thereby gain insight into how science contributes to one's understanding

of the world. Teaching should build on the students' own experiences, observations, and experiments to provide them with practical skills, encourage creativity, and nurture their ability to cooperate with others. In this way, the subject should develop students' understanding of human interaction with nature and encourage them to engage and act in ways that support sustainable development.[23]

As is the case for mathematics, the curriculum for nature and technology is structured according to common objectives that encompass fields of competence, domains of skills and knowledge, and skill and knowledge objectives. There are four fields of competence with corresponding competence goals, as shown in Exhibit 3.

**Exhibit 3: Fields of Competence and Competence Goals, Science**

| Field of Competence | After Grade 2 | After Grade 4 | After Grade 6 |
|---|---|---|---|
| Inquiry | The student can conduct simple experiments based on his/her own and others' questions. | The student can conduct simple inquiries based on his/her own expectations. | The student can design experiments based on emerging hypothesis formation. |
| Modeling | The student can use lifelike models. | The student can apply models with an increasing level of abstraction. | The student can design simple models. |
| Perspectivation | The student can recognize nature and technology in everyday life. | The student can relate nature and technology to other contexts. | The student can relate nature and technology to the outside world and current events. |
| Communication | The student can describe his/her own inquiries and models. | The student can describe simple problems within natural science and technology. | The student can communicate about nature and technology. |

Each field of competence is divided into three to six domains of skills and knowledge for Grades 2, 4, and 6, as shown in Exhibit 4. Some domains of skills and knowledge are only found in one field of competence, while others occur in more than one.[24,25]

**Exhibit 4: Domains of Skills and Knowledge, Science**

| Field of Competence | Domains of Skills and Knowledge | Grade 2 | Grade 4 | Grade 6 |
|---|---|---|---|---|
| Inquiry | Studies in Science | X | X | X |
| | Technology and Resources | X | X | X |
| | Human Beings | X | X | X |
| | Organisms | X | | |
| | Water, Air, and Weather | X | X | |
| | Nature Locally and Globally | | X | |
| | Nature and Environment | | | X |
| | Matter and Energy | | | X |
| Modeling | Scientific Modeling | X | X | X |
| | Technology and Resources | X | X | X |
| | Human Beings | X | X | X |
| | Organisms | X | | |
| | Water, Air, and Weather | X | X | |
| | Nature Locally and Globally | | X | |
| | Earth and the Solar System | | X | |
| | Nature and Environment | | | X |
| | Matter and Energy | | | X |
| | Transformation of Earth | | | X |
| Perspectivation | Perspectivation in Science | X | X | X |
| | Technology and Resources | X | X | X |
| | Human Beings | X | X | X |
| | Organisms | X | | |
| | Water, Air, and Weather | X | X | |
| | Nature Locally and Globally | | X | |
| | Earth and the Solar System | | X | |
| | Nature and Environment | | | X |
| | Matter and Energy | | | X |
| | Transformation of Earth | | | X |
| Communication | Presentation | X | X | X |
| | Knowledge of Subject-Specific Terminology | X | X | X |
| | Academic Reading and Writing | X | X | X |

The three subjects taught from Grades 7 to 9, geography, biology, and physics/chemistry, are included in the final exams that conclude *folkeskolen*.[26] Through these subjects, students should develop competencies within the discipline and thereby gain an insight into how each subject contributes to one's understanding of the world. The three subjects ought to expand on what the students have learned from prior instruction in nature and technology. Teaching should be based on students' personal observations and inquiries, including fieldwork, to cultivate their curiosity and interest in the subject, fostering a desire for further learning in science and technology. Students should come to the realization that science and technology are part of one's culture and worldview and thereby further develop their sense of responsibility for nature

and the use of natural resources. In this way, they can increase their confidence in their own ability to make decisions and act in relation to sustainable development and human interaction with nature.[27,28,29]

## Teacher Professional Development Requirements and Programs

There are no officially mandated requirements for the continuous professional development of teachers in Denmark. However, university colleges offer a variety of professional development courses, ranging from 1-day workshops to diploma programs, which can amount to either 15 or 60 European Credit Transfer and Accumulation System (ECTS) points. Additionally, private consultants offer a wide array of short courses, although these tend to be less focused on specific subject content. The availability of these professional development opportunities primarily depends on the budget allocated for such activities at individual schools or by municipalities.

Although the Folkeskole Act states that teachers in public schools (*folkeskoler*) must hold a professional Bachelor of Education degree approved by the Danish Ministry of Children and Education,[30] in recent years, there has been an increasing number of teachers without relevant teaching qualifications in the academic subjects they teach. In academic year 2022–2023, 86.6% of classes taught in public schools were taught by a teacher with relevant qualifications in the specific subject, yet this number disguises significant variation between subjects. In mathematics, 94.1% of teachers had relevant qualifications in the subject, while only 66.5% of nature and technology teachers had relevant qualifications in the subject.[31]

## Monitoring Student Progress in Mathematics and Science

Since the turn of the millennium, there has been an increased focus on monitoring student progress in public schools in Denmark.[32] The current Folkeskole Act (*Folkeskoleloven*) contains regulations for monitoring an individual student's progress and communicating this progress to the student's parents. The act also provides regulations for the general monitoring of progress in relation to the individual public school and administrative unit of the school system, the local municipality.[33] According to the Folkeskole Act, the student and his or her parents should be regularly informed of the student's overall progress by teachers and, if relevant, by the school principal. This includes a written presentation of the student's results on national tests.[34] In mathematics, national tests take place in Grades 2, 4, 6, 7, and 8. Schools also have the opportunity to use the national test system for optional tests in biology and geography in Grade 8. There are no national tests in nature and technology.

As part of their teaching, schools have a duty to continuously evaluate each student's progress in relation to the curriculum as described in the Common Objectives and to use this information as a tool to formatively guide the student. Parents must be notified based on this ongoing monitoring of student progress. In Grade 8, student monitoring includes term marks at least twice a year until the final exams at the end of Grade 9 (or Grade 10 for

students taking the optional extra year).[35] The monitoring of student progress also includes national test results and a national student well-being survey, which serve as the foundation for assessment at both the school and municipal levels. According to the Folkeskole Act, the Ministry of Children and Education must report school-level results for national tests to the school and the municipality, including results corrected to reflect between-school differences in students' social backgrounds. Alongside national test results and the well-being survey, many municipalities and schools monitor students' progress in other ways. The design of these monitoring systems varies between municipalities and can also vary between schools within a municipality. However, the monitoring systems tend to focus on literacy and numeracy and only include science subjects to a minimal degree (if at all). They are often based on locally used test systems, e.g., commercially available standardized tests in mathematics.[36]

## Special Initiatives in Mathematics and Science Education

In 2018, the Danish government launched a national science strategy with the purpose of aligning teaching in the science subjects across primary, secondary, and tertiary education. The strategy has aimed to strengthen the collaboration between education and industry. One of the strategy's objectives is to increase the number of students who choose science, technology, engineering, and mathematics (STEM) subjects in upper secondary school and pursue STEM-oriented vocational training programs. Another objective is to increase the number of students who achieve a high proficiency level in STEM subjects in primary and lower secondary education. The strategy includes several initiatives at different education levels. At the primary level, the main initiatives are to increase the focus on general educational aspects of science, including introducing students to the basic principles of natural science, important natural scientists, and landmark discoveries and inventions, as well as to strengthen teacher training in the natural science subjects.[37]

In November 2022, a status report focusing on Denmark's national science strategy was published.[38] Highlights from the report include the following:

- Experts have collaborated to create "The ABC of Natural Science," which consists of teaching materials and inspiration for schoolteachers and is designed to improve students' comprehension of science.
- To enhance teacher competence, practical professional development programs for primary school teachers have been implemented, with an emphasis on inquiry-based learning.
- E-learning modules and teaching courses have been introduced to support ongoing professional development.
- Thematic teaching packages have enriched teaching resources available to primary schools.
- In 2020, a new master's program for primary school science teachers was initiated.

- A network has been established for science coordinators at upper secondary schools to foster collaboration with researchers and further enhance STEM education.
- A trial program on a new subject called *Teknologiforståelse* (technology understanding) concluded in 2021, aimed at integrating technology comprehension into primary school education.

Regarding the latter, while both teachers and students valued technology understanding, its incorporation was found to be challenging. Political discussions are taking place about introducing it as an elective subject in primary schools. Furthermore, digital exams in physics/chemistry, biology, and geography have been expanded and improved. A 2-year trial, originally scheduled for 2020–2021 and 2021–2022 but postponed due to COVID-19 disruptions, aims to further enhance exams by incorporating free-text responses and interactive laboratory simulations.[39]

Progress in achieving the goals of the national science strategy is tracked through various indicators. Surveys assessing students' levels of interest and motivation in science began in 2018–2019 but were interrupted by COVID-19. Data on students' choice of science subjects indicate a significant proportion opting for STEM-focused education in 2020 and 2021. The percentage of students pursuing STEM-focused vocational education remained stable from 2019 to 2021. Data on students' proficiency in STEM include their performance in joint science examinations in lower secondary school and average grades in science, showing a slight increase from 2017–2018 to 2020–2021.[40]

In December 2019, the Ministry of Children and Education announced the creation and financing of a new research center focusing on the development of mathematics teaching, *Nationalt center for udvikling af matematikundervisning* (NCUM).[41] This new center is based at the Danish School of Education, Aarhus University, and will be financed for a period of 5 years.[42]

NCUM aims to provide a nexus for interaction between educators, teachers, instructors, and researchers to develop practices in early childhood education and mathematics teaching in primary and secondary education.[43] NCUM has three main tasks:

1. NCUM disseminates research-based knowledge about mathematics instruction to educators and instructors in ways that provide inspiration and a basis for developing and reflecting on practice. Furthermore, NCUM provides an overview of current Danish development and research projects within the field, including PhD projects.
2. NCUM establishes and supports new networks for educators and mathematics teachers with a focus on developing practices based on mathematical didactic knowledge. These networks are utilized in the development and implementation of NCUM's projects.
3. NCUM initiates development and research projects that lay the foundation for the development of practices in early childhood, primary, and secondary education, and promote a culture of collaboration. The projects are anchored locally and have broad geographical coverage across Denmark. A central element in NCUM's projects is to

support collaboration between educators, mathematics teachers, and researchers in the development of practices in early childhood education and mathematics teaching.

Private foundations have supported an initiative called *Naturfagsakademiet* (the Science Academy) to enhance science education (with DKK 200 million) based on three pillars: (1) strengthening in-school education, (2) enhancing teacher training within the field of science education (for both primary and secondary subjects), and (3) advancing research in science education. This initiative is a collaboration among all teacher training programs in Denmark and four universities with research environments focused on STEM education.[44]

## Suggested Reading

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