Co-funded by the Erasmus+ Programme of the European Union

TÜRKİYE ULUSAL AJANSI
TURKISH NATIONAL AGENCY

Comparative Situation Report on Partner Countries' Education Systems, Scientific Literacy and Core Competencies

Integration of Educational Robotics to Scientific Learning Teaching Process

2020-1-TR01-KA201-092601

SCIENCE e-ROBOT

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1- INTRODUCTION

1.1. PROJECT GENERAL PURPOSE

In order to increase the level of acquisition of 21st century basic skills, the aim of this project is to increase the quality of education by contributing to the integration of technology into the learning and teaching process; To improve scientific literacy within the consortium by contributing to the development of basic competencies by integrating educational robotics technology into scientific learning and teaching process.

1.2. PROJECT OBJECTIVES

1- Developing an innovative science learning-teaching strategy compatible with the educational context of the partner countries related to the scientific learning teaching process in which educational robotics is integrated for the target groups by developing 3 intellectual outputs,

2- Increasing the knowledge and skills of 42 staff from partner organizations on different teaching models, measurement and evaluation and robotic methods / techniques in interdisciplinary science teaching,

3- By organizing 5 large-scale multiplier activities and other dissemination activities; Improving the knowledge skills of at least 200 Science teachers, 50 teacher candidates and 100 experts on the use of intellectual outputs developed under this partnership,

4- Developing basic competence and scientific literacy of 10-17 age group students through educational robotics,

5- To develop long-term innovative cooperation between partners.

1.3. CONCORTIUM STRUCTURE

Project Coordinator

HADİYE KURADACI SCIENCE AND ART CENTER

Partners – Consortium Members

1- MINISTRY OF EDUCATION GENERAL DIRECTORATE OF SPECIAL EDUCATION AND GUIDANCE SERVICES
2- MERSİN UNIVERSITY
3- LICEUL NATIONAL DE INFORMATICA ARAD
4- ISTITUTO ISTRUZIONE SCOLASTICA SUPERIORE “CARLO ALBERTO DALLA CHIESA”
5- AGRUPAMENTO DE ESCOLAS DE PORTELA E MOSCAVIDE
6- ROBYCODE UG

1.4. MAIN ACTIVITIES IN THE SCOPE OF THE PROJECT

The project will include 3 transnational project meetings, 2 short-term staff training and 5 dissemination activities (multiplier events). As an innovative trend among the project results, we have 3 important intellectual outputs such as e-Workbook open education resource, methodological guide for implementation and comprehensive assessment and evaluation toolset.

1.5. PROJECT INTELLECTUAL OUTPUTS

1- Integration of Educational Robotics into the Scientific Learning Teaching Process Open Education Resource (OER) - It is pedagogically compatible with the target group age levels and triggers the creativity and critical thinking of the student; It can be easily implemented by teachers and students where there are activities that require problem-solving skills to work and enable collaboration; improves the basic competencies of teachers and students, has been adapted to various scientific themes and sub-subject areas in different modern teaching models, and has a positive attitude towards science and has learning and teaching scenarios for individuals. e-Workbook platform, which provides dynamic, personalized teaching - learning and user convenience, which will influence innovative science activities with robotics content.

2- Practical Methodological Guidelines for Robotic Assisted Science Teaching - Helps overcome the obstacles to gain students' acquisition of scientific theme and sub-subject areas for the target group age levels determined by the partners; A practical guide to the project partners and in English, describing the application of robotic pattern science activities in various modern teaching models and providing guidance in the use of the open educational resource.

3- Comprehensive Measurement and Evaluation Toolkit - Testing robotic supported science learning activities; It will provide guidance on assessing their strengths and weaknesses.

2- PARTNER COUNTRIES' EDUCATION SYSTEMS AND SCIENCE CURRICULUM

TURKEY

RECENT POLICIES AND PRACTICES

The Turkish education system is both comparatively large and highly centralised, covering over 1 million teachers and 18 million students in 2018/19. The Ministry of National Education (MoNE) is responsible for pre-primary (ISCED 02) to upper secondary level education, and adult education (OECD, 2020).

Turkey's For a Stronger Tomorrow: Education Vision 2023 (2018) promotes a holistic, human-centred approach to education. The 8 concrete targets address many of the challenges raised in this profile (OECD, 2020, p.18-19):

1) Reduce gaps between schools

2) Improve school learning environments

3) Improve the attractiveness of VET

4) Reduce exam pressure

5) Develop 21st century skills

6) Improve educators' job satisfaction

7) Expand ECEC (Early childhood education and care)

8) Improve inclusive practices for students with special educational needs.

The vision establishes 44 sub-goals, each with a rough policy timeline, often including piloting phases

Since 2010, the MoNE has developed five-year strategic plans establishing medium-term goals to inform work at the central, provincial and district levels. The plans assign quantitative progress indicators, responsible actors and financial resources to each goal; the MoNE publishes annual progress reports. While the first strategic plan (2010-14) focused on access, the second (2015-19) emphasised quality and institutional capacity. To develop the latter, the MoNE consulted around 38 000 internal stakeholders (educators and administrators) and 35 000 external stakeholders (students, parents and academics). An evaluation praised the focus on disadvantaged groups and good governance while noting gaps in performance indicators and funding. The third plan (2019-23) aims to improve transitions to tertiary and employment, as well as support for special educational needs, and modernise structures for greater efficiency (OECD, 2020 p.18-19).

Coordinated by the Board of Education, the latest curricular revisions (2018) emphasise 21st century competences, reducing curriculum overload and enhancing labour market relevance. The revisions also took into account the knowledge and skills required for the information age, diversity in teacher competences and student needs in different types of schools across different regions, and alignment with the Turkish Qualifications Framework (TQF) (OECD, 2020, p.18-19).

TQF design has taken into account the philosophy and structure of the Turkish education and training system as well as its basic features directly associated with the TQF. As per the Principal Law on National Education no 1739, the national education system has been designed to have an integrated structure to serve for the needs of individuals, and it comprises of “formal education and training” provided by providers of in pre-school, primary, lower secondary, upper secondary and higher education; and also “non-formal education and training” provided under the scope of lifelong learning.

Most stages in the formal and non-formal education system can be reached by distance learning and open education options (TQF, 2015, p. 4-5)

Formal education encompasses formal programmes of pre-school, primary, secondary and higher education. The twelve-year compulsory formal education and training5, which follows optional preschool education, has been divided into the following stages (TQF, 2015, p. 4-5):

- Primary Education
  - Primary School (4 years)
  - Lower Secondary School (4 years)
- Upper Secondary Education
  - High School (4 years)

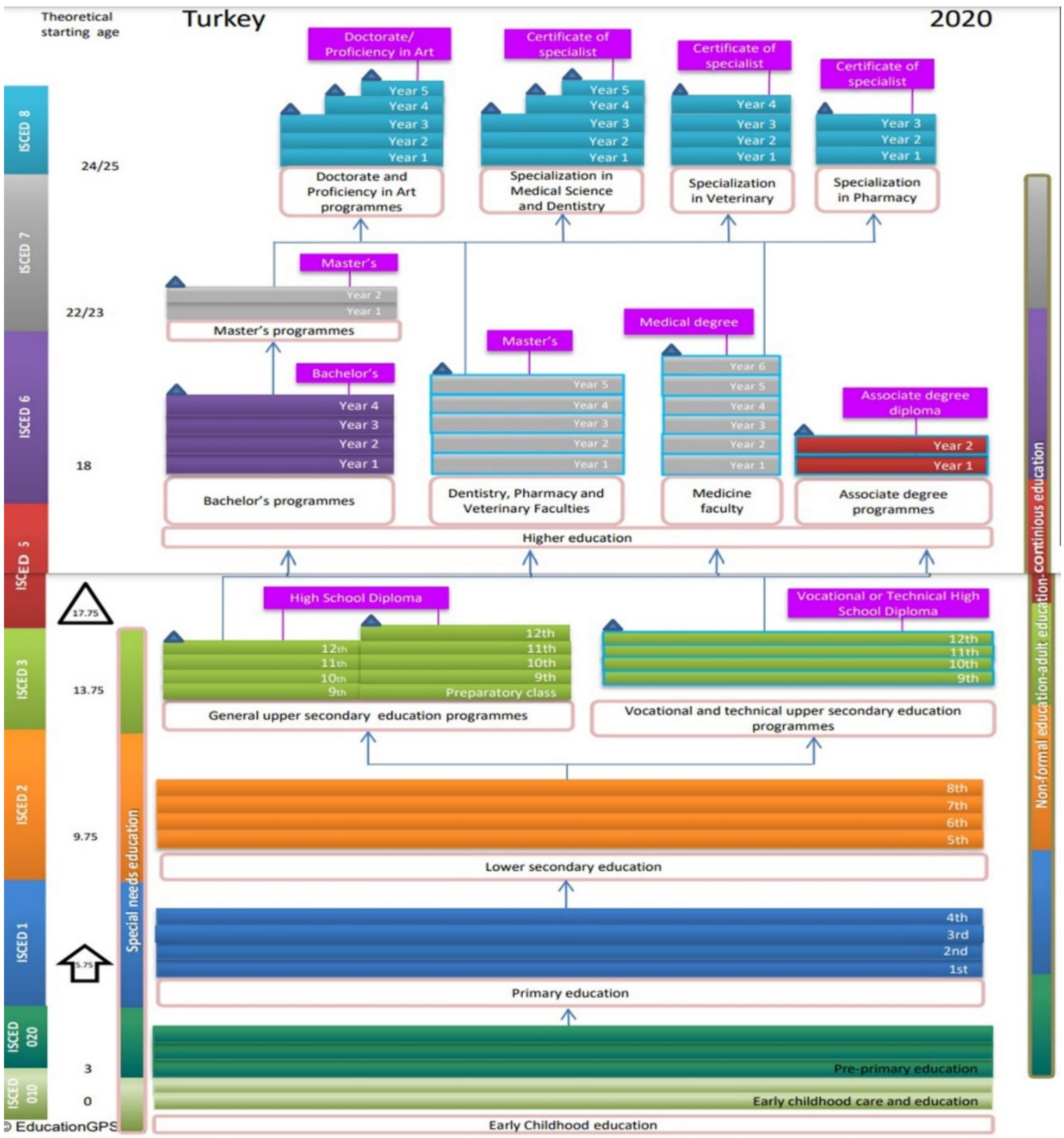
The following are provided by education and training providers under the Ministry of National Education (MoNE) and also by private and other providers supervised by MoNE;

  - General Upper Secondary Education
  - Vocational and Technical Upper Secondary Education
  - Upper Secondary Education programmes offering both general and vocational education.
- Higher Education

Higher education in Turkey covers all academic and vocational education and training after secondary education coordinated by the Council of Higher Education (CoHE) and provided by higher education institutions. Higher education consists of the three main cycles (Bachelor's, Master's and

Doctorate) and the short cycle (Associate Degree) defined in the context of the Bologna Process. Except for Dentistry, Pharmacology, Medicine and Veterinary programmes, in which first and second cycles (Bachelor's and Master's) are integrated, other higher education programs are organized in a three-cycle (Bachelor's, Master's and Doctorate) structure.

Chart 1. OECD (2018), "Turkey: Overview of the Education System", OECD Education GPS, http://gpseducation.oecd.org/Content/MapOfEducationSystem/TUR/TUR_2011_EN.pdf.



THE TURKEY K-12 EDUCATION SYSTEM

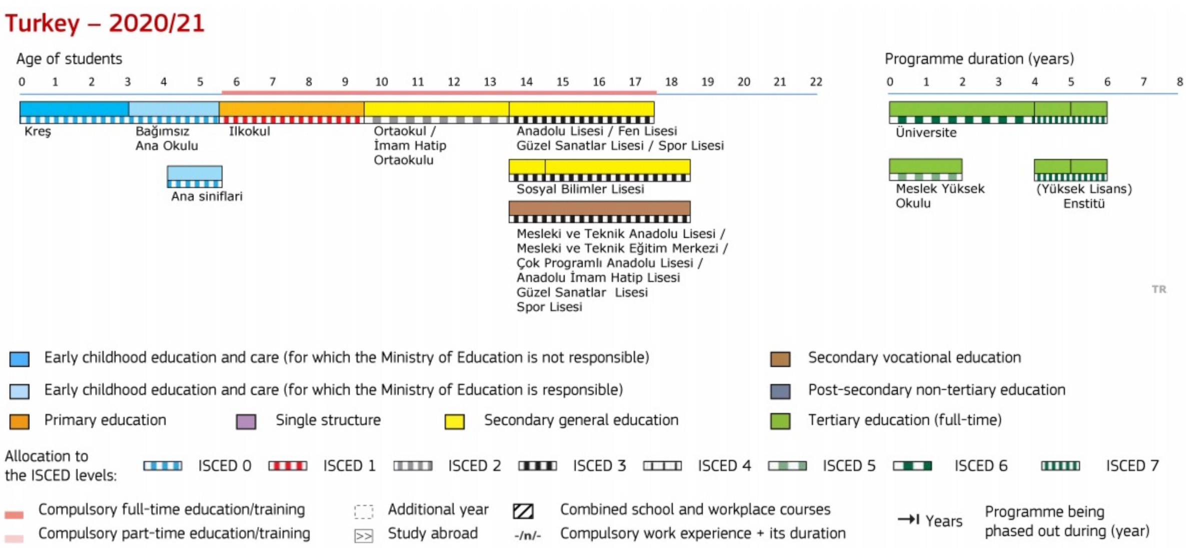
The Ministry of National Education administers the K-12 education system in Turkey. In Turkey, compulsory education lasts for 12 years, and after that students may go for higher education. The K-12 education system of Turkey comprises of (https://www.turkeyeducation.info/):

Pre-primary education: This K-12 educational level is optional and for children aged 3 to 6

Primary education: This K-12 educational level is compulsory for all children aged 6 to 14.

Secondary education: This K-12 educational level is compulsory for children aged 14 to 18 and includes general, technical and vocational high schools.

Chart 2. Structure of the Turkey National Education System



SECONDARY EDUCATION SYSTEM IN TURKEY

Primary Education

The primary education in Turkey provides basic skills and knowledge. This educational level is compulsory to attend, and is free at state schools.

Ages: 6 to 14

Duration: 8 years

Grades: 1 to 8

Primary education in Turkey is divided into 2 levels of 4 years each:

Level 1: Covers grades 1 to 4, and is for students aged 6 to 9

Level 2: Covers grades 5 to 8, and is for students aged 10 to 14

At primary schools, basics of many subjects are taught. From grade 4, foreign language is taught. English, German or French classes are also held. Till grade 6, a single teacher teaches all the subjects to Turkish pupils. From grade 7 onwards, different teachers are present to teach different subjects.

Curriculum: Mathematics, science, a foreign language - German, English or French; traffic safety and first aid; Turkish language and literature; religious culture and ethics, arts; social studies, physical education, human rights and civics; individual and group activities; music; sciences, Turkish history and Ataturk's reforms; and elective subject.

Certificate awarded: Upon successful completion of primary education, students are awarded a primary education diploma.

SCIENCE EDUCATION PROGRAM IN TURKEY FOR SECONDARY EDUCATION

The main objectives of the Science Curriculum, which aims to train all individuals as science literate, are as follows:

1. To provide basic information about astronomy, biology, physics, chemistry, earth and environmental sciences, science and engineering applications,

2.In the process of discovering nature and understanding the relationship between human and environment, adopting scientific process skills and scientific research approach and finding solutions to the problems encountered in these areas,

3. To realize the mutual interaction between the individual, the environment and the society; To develop awareness of sustainable development regarding society, economy and natural resources,

4. To ensure taking responsibility for daily life problems and using knowledge of science, scientific process skills and other life skills in solving these problems,

5. Developing career awareness and entrepreneurship skills related to science,

6. To help scientists understand how scientific knowledge is created, the processes through which this information is created and how it is used in new research,

7. To arouse interest and curiosity about events occurring in nature and its immediate surroundings, to develop an attitude,

8. To create an awareness of safe working by realizing the importance of safety in scientific studies,

9. To develop reasoning ability, scientific thinking habits and decision-making skills by using socioscientific issues,

10. To ensure the adoption of universal moral values, national and cultural values and scientific ethical principles.

Core Currriculum

The secondary education raise awareness to contribute to the society, provide cultural education, help students to identify and solve social and individual problems, and also prepares pupils for higher education (https://www.turkeyeducation.info/)

Ages: 14 to 18
Grades: 9 to 12
Duration: 4 years

Upper Secondary Education covers Anatolian High School, Science High School, School of Fine Arts, Sports High School, School of Social Sciences, the Anatolian Religious High Schools and High Schools conducting vocational and technical programs. Such training is aimed at children aged 14 to 18 years and at those who are above 18 in Vocational Education Centres and it is the responsibility of General Directorate of Secondary Education, the General Directorate of Vocational and Technical Education and General Directorate of Religious Education. Furthermore, schools conducting special training programs for the training of persons with disabilities and special educational institutions are under the responsibility of the General Directorate of Secondary and High School Level and Special Education and Guidance Services https://eacea.ec.europa.eu/national-policies/eurydice/content/turkey_en).

Core Curriculum (https://www.turkeyeducation.info/):

In grade 9, core curriculum is followed: Mathematics, biology, religious education and ethics, chemistry, history, foreign language, philosophy, visual arts and music, health, geography, physics, military science, health, Turkish language and literature, traffic and first aid, and physical education.

In grade 10, 11 and 12, there are common courses as well as electives.

Elective courses: Turkish literature, modern Turkish and world history, history, language and expression, foreign language, chemistry, mathematics, logic, psychology, geometry, second foreign language, biology, sociology, and physics.

The following aims and functions of secondary education are given in accordance with the general aims and basic principles of the National Education (https://eacea.ec.europa.eu/national-policies/eurydice/content/upper-secondary-and-post-secondary-non-tertiary-education-44_en):

1. Providing the minimum education by giving common general knowledge to all students at secondary level people to recognize social problems, to seek solutions and international economic, social and cultural awareness to contribute to the development and to gain the power,

2. Students, various programs and interests in school and in accordance with the extent of competencies and abilities to prepare them for higher education or vocational and higher education for both life and business

In this context,

a) To prepare students for the future with the knowledge, skills and physical, mental, moral, spiritual, social and cultural characteristics of the development towards democracy and respect for human rights,

b) To prepare students at the secondary level for life and business area for higher education by providing a common public culture and professional skills,

c) To ensure a dynamic, healthy and balanced structure in accordance with the principles and policies of the Ministry of National Education,

d) To develop students' self-confidence, self-control and sense of responsibility,

e) To develop students' habit of work and solidarity,

f) Students are able to learn a foreign language to follow the developments and changes in the world,

g) To enable students to produce knowledge to develop projects by using the knowledge and skills,

h)To provide efficient education by making use of the technology

i) To encourage individuals to adopt the principles of lifelong learning

j) To aim to encourage production and ensure compliance with international standards and certification of services

The vision of 2023 in the field of education is as follows (TÜBİTAK, 2004):

"Developing the creativity and imagination of the individual; that each individual can improve himself at the highest level in line with his characteristics by observing and evaluating individual differences; independent of time and place, has created its own unique learning technologies and has the power to renew itself with its flexibility of change; To have a learning and people-oriented education system".

Table 1. 5th Grade Program

5th Grade				
	No	**Unit Name**	**Subject Area Name**	**Time**
	* According to the instructions in the Science, Engineering and Entrepreneurship Applications section, students are expected to make applications during the year.			**Percentage (%)**
Science, Engineering and Entrepreneurship Applications	1	Sun, Earth and Moon	Earth and Universe	16,6
	2	World of Living	Creatures and Life	8,3
	3	Measurement of Force and Friction	Physical Events	8,3
	4	Matter and Change	Matter and Its Nature	18,1
	5	Spread of Light	Physical Events	15,3
	6	Human and Environment	Creatures and Life	13,9
	7	Electrical Circuit Elements	Physical Events	11,1
	Science, Engineering and Entrepreneurship Practices: End of Year Science Festival (Students are expected to present their product effectively during the year.)			8,3
			Total	100

Table 2. 6th Grade Program

6th Grade				
	No	**Unit Name**	**Subject Area Name**	**Time**
	* According to the instructions in the Science, Engineering and Entrepreneurship Applications section, students are expected to make applications during the year.			**Percentage (%)**
Science, Engineering and Entrepreneurship Applications	1	Solar System and Eclipses	Earth and Universe	9,7
	2	Systems in Our Body	Creatures and Life	16,7
	3	Force and Motion	Physical Events	9,7
	4	Matter and Heat	Matter and Its Nature	19,4
	5	Sound and Features	Physical Events	15,3
	6	Systems in Our Body and Their Health	Creatures and Life	12,5
	7	Transmission of Electricity	Physical Events	8,3
	Science, Engineering and Entrepreneurship Practices: End of Year Science Festival (Students are expected to present their product effectively during the year.)			8,3
			Total	100

Table 3. 7th Grade Program

7th Grade				
	No	**Unit Name**	**Subject Area Name**	**Time**
	* According to the instructions in the Science, Engineering and Entrepreneurship Applications section, students are expected to make applications during the year.			**Percentage (%)**
Science, Engineering and Entrepreneurship Applications	1	Solar System and Beyond	Earth and Universe	11,1
	2	Cell and Divisions	Creatures and Life	11,1
	3	Force and Energy	Physical Events	13,9
	4	Pure Substances and Mixtures	Matter and Its Nature	19,4
	5	The Interaction of Light with Matter	Physical Events	18,05
	6	Reproduction, Growth and Development in Living Organisms	Creatures and Life	12,5
	7	Electric Circuits	Physical Events	5,6
	Science, Engineering and Entrepreneurship Practices: End of Year Science Festival (Students are expected to present their product effectively during the year.)			8,3
			Total	100

Table 4. 8th Grade Program

8th Grade				
	No	**Unit Name**	**Subject Area Name**	**Time**
	* According to the instructions in the Science, Engineering and Entrepreneurship Applications section, students are expected to make applications during the year.			**Percentage (%)**
Science, Engineering and Entrepreneurship Applications	1	Seasons and Climate	Earth and Universe	9,7
	2	DNA and Genetic Code	Creatures and Life	15,3
	3	Pressure	Physical Events	6,9
	4	Matter and Industry	Matter and Its Nature	19,4
	5	Simple Machines	Physical Events	6,9
	6	Energy Conversions and Environmental Science	Creatures and Life	16,7
	7	Electric Charges and Electric Energy	Physical Events	16,7
	Science, Engineering and Entrepreneurship Practices: End of Year Science Festival (Students are expected to present their product effectively during the year.)			8,3
			Total	100

ITALY

THE ITALIAN EDUCATION SYSTEM (Diagram of the education system)

The Italian education and training system is organized on the basis of the principles of subsidiarity and the autonomy of educational institutions.

The State has exclusive legislative competence for the "general rules on education" and for the determination of the essential levels of services that must be guaranteed throughout the national territory. Furthermore, the State defines the fundamental principles that the Regions must respect in the exercise of their specific competences. The Regions have concurrent legislative power in the field of education and exclusive in the field of education and vocational training. State educational institutions have didactic, organizational, research, experimentation and development autonomy.

The education system is organized as follows:

- Zero-six-year integrated system, not compulsory, with a total duration of 6 years, divided into:
- Educational services for children¸ managed by local authorities, directly or through the stipulation of agreements, by other public or private entities, which welcome children between three and thirty-six months;
- Kindergarten, which can be managed by the state, by local authorities, directly or through the stipulation of agreements, by other public or private bodies, which welcomes children between three and six years of age;

- First compulsory education cycle, lasting a total of 8 years, divided into:
- Five-year primary school¸, for pupils aged 6 to 11;
- First grade secondary school, lasting three years, for pupils aged 11 to 14;
- Second cycle of education divided into two types of pathways:
- Second grade secondary school, lasting five years, for female students and students who have successfully completed the first cycle of education. The schools organize high school, technical institutes and vocational institutes courses for female students aged 14 to 19;
- Three-year and four-year courses of vocational education and training (IeFP) of regional competence, always aimed at female students and students who have successfully completed the first cycle of education.
- Compulsory education

Compulsory education lasts 10 years, from 6 to 16 years of age, and includes the eight years of the first cycle of education and the first two years of the second cycle (Law 296 of 2006), which can be attended in secondary school second degree - state - or in regional education and vocational training courses. Furthermore, for all young people the right / duty of education and training applies for at least 12 years or, in any case, until the achievement of a three-year professional qualification by the age of 18 according to the provisions of law 53 / 2003. Compulsory education can be carried out in state schools and in peer schools (Law 62 of 2000), which make up the public education system, but it can also be fulfilled in non-peer schools (Law 27 of 2006) or through family education. . In the latter two cases, however, the fulfillment of the education obligation must be subject to a series of conditions, such as the carrying out of suitability tests. Parents of pupils and pupils, or whoever exercises parental responsibility, are responsible for the fulfillment of the obligation to educate minors, while the Municipalities of residence and the school directors of the schools in which they are enrolled pupils and pupils. At the end of the compulsory education period, usually foreseen at the end of the second year of upper secondary school, if the student does not continue their studies, a certification of the skills acquired is issued (Ministerial Decree 139 of 2007). After passing the final state examination of upper secondary education, the student can access tertiary education courses (university, Afam and ITS). Some university courses are limited and students must pass an entrance test.

Non-state education

The Article 33 of the Italian Constitution establishes two fundamental principles: the obligation, for the State, to offer a state school system to all young people and the right, for natural and legal persons, to create schools and educational institutions free of charge. for the state. Equal schools are authorized to issue qualifications with the same legal value as those of the corresponding state schools; they have full freedom with regard to cultural orientation and pedagogical-didactic direction and benefit from a more favorable tax treatment if they are not for profit.

Table 5: II.SS. "Carlo Alberto Dalla Chiesa" Physics Curriculum

Course: First Biennium
Students' age: 14-16
Science Lyceum
Subject: Physics

Content			**Competences**
N.	General topic	Specific topic	
1	The language of physics	Measures and errors Errors' propagation Forces	**Knowledge – Methodology- Application** **Observe and identify a phaenomenon** - Measure and calculate errors

		Vectors	- Use of the subject microlanguage with confidence a clarity **Communication** - Use of the subject's microlanguage in various contexts; - Understand priorities, define strategies and verify results; - Comprehend and analyse a range of different texts; - Find links to other subjects and everyday life; **Relationship** - Put data into relationship in order to understand and analyse the information
2	Mechanics	Balance of a material point; Fluids' balance; Rectilinear motion from the kinematic point of view; Uniform circular motion; Principles of dynamics;	**Knowledge – Methodology- Application** - Formulate explanatory hypotheses using models, analogies and laws - Formalize a physics problem and apply the mathematical and disciplinary tools relevant to its resolution - Experience and explain the significance of the various aspects of the experimental method - Develop curiosity and aptitude for research, observation and reasoning skills. **Communication** - Collaborate and interact; - Knowing how to use a specific language in different areas and have clarity of presentation. **Relationship** - Put data into relationship in order to understand and analyse the information - Develop group work abilities
3	Conservation of mechanic energy	Work and forms of energy; First discussion of the law of conservation of mechanical energy;	**Knowledge – Methodology- Application** - Recognize and explain the conservation of energy - Formalize a problem of physics and apply the maths and other subjects tools relevant to its solution **Communication** - Collaborate and interact; - Knowing how to use a specific language in different areas and have clarity of presentation. **Relationship** - Put data into relationship in order to understand and analyse the information - Develop group work abilities
4	Thermal phenomena	Temperature and heat Thermal equilibrium State transitions	**Knowledge – Methodology- Application** - Use of the laws of heat exchange to determine the equilibrium temperature of a system or the specific heat of a substance. - Apply the laws that describe heat exchanges during state changes. **Communication** - Collaborate and interact; - Knowing how to use a specific language in different areas and have clarity of presentation. **Relationship** - Put data into relationship in order to understand and analyse the information - Develop group work abilities

5	Light phenomena	Reflection and refraction of light Operation of optical instruments	**Knowledge – Methodology- Application** - Apply the laws of reflection and refraction; **Communication** - Collaborate and interact; - Knowing how to use a specific language in different areas and have clarity of presentation. **Relationship** - Put data into relationship in order to understand and analyse the information - Develop group work abilities
	Thermal balance	Temperature and heat Thermal balance State transitions	**Knowledge – Methodology- Application** - Use the laws of heat exchange to determine the equilibrium temperature of a system or the specific heat of a substance. - Apply the laws that describe heat exchanges during state transitions; **Communication** - Collaborate and interact; - Knowing how to use a specific language in different areas and have clarity of presentation. **Relationship** - Put data into relationship in order to understand and analyse the information - Develop group work abilities

Table 6: II.SS. "Carlo Alberto Dalla Chiesa" Physics Curriculum

Course: Second Biennium

Students' age: 16-18

Science Lyceum

Subject: Physics

Content			Competences
N.	General topic	Specific topic	
1	Motion	Laws of motion; Principles of dynamics; Inertial and non-inertial references; Momentum; Principle of conservation of energy and momentum. One-dimensional collisions Fluid dynamics and the Bernoulli equation Kepler's laws Universal gravitation	**Knowledge – Methodology- Application** - Apply laws to solve simple problems - Acquired an autonomous, flexible and critical method of study **Communication** - Develop curiosity and aptitude for research, observation and reasoning skills - Know how to select - information in a critical and conscious way - Include the supporting structures of the argumentative and demonstrative procedures of mathematics, also through the mastery of the logical-formal language; - identify and solving problems **Relationship** - Put data into relationship in order to understand and analyse the information

2	Thermodynamics	Heat propagation Thermal expansion Gas laws Principles of thermodynamics Thermal machines and performance	**Knowledge – Methodology- Application** - Apply the laws of reflection and refraction; **Communication** - Develop curiosity and aptitude for research, observation and reasoning skills - Know how to select - information in a critical and conscious way - Include the supporting structures of the argumentative and demonstrative procedures of mathematics, also through the mastery of the logical-formal language; - Know how to use them in solving problems of various kinds - Collaborate and interact; - Know how to use a specific language in different areas and have clarity of presentation. **Relationship** - Put data into relationship in order to understand and analyse the information - Develop group work abilities
3	Wave phenomena	- Characteristic quantities of waves and related laws - Wave propagation - Reflection and refraction of light - The sound and the Doppler effect	**Knowledge – Methodology- Application** - Apply laws to solve simple problems - Acquire an autonomous, flexible and critical method of study **Communication** - Collaborate and interact; - Knowing how to use a specific language in different areas and have clarity of presentation. **Relationship** - Put data into relationship in order to understand and analyse the information - Develop group work abilities
4	Electromagnetism	Laws of electrostatics Electrostatic field Continuous electric current Read about circuits Joule effect Magnetic phenomena Magnetic field Current-magnet interaction Motion of electric charges in a magnetic field	**Knowledge – Methodology- Application** - Apply laws to solve simple problems - Acquire an autonomous, flexible and critical method of study **Communication** - Collaborate and interact; - Knowing how to use a specific language in different areas and have clarity of presentation. **Relationship** - Put data into relationship in order to understand and analyse the information - Develop group work abilities

Table 7: II.SS. "Carlo Alberto Dalla Chiesa" Physics Curriculum

Course: Fifth Year
Students' age: 18-19
Science Lyceum
Subject: Physics

Content			**Competences**
N.	General topic	Specific topic	
1	Energy and Electromagnetism	Electromagnetic induction Alternating currents	**KNOWLEDGE** Analyze magnetic and electromagnetic phenomena

		Circuits L-C Transport of current Maxwell's equations Electromagnetic waves	develop curiosity and aptitude for research, observation and reasoning skills Knows how to select information in a critical and conscious way Understand the supporting structures of the argumentative and demonstrative procedures of mathematics, also through the mastery of logical-formal language Know how to use them in particular in identifying and solving problems of various kinds **OPERATIONAL METHODOLOGY:** Apply laws to solve simple problems Acquire an autonomous, flexible and critical method of study **LINGUISTIC-COMMUNICATIVE:** Know how to use a specific language and possess expository clarity
2	Relativity	Einstein's special relativity: time dilation and length contraction Mass-energy equivalence Energetic interpretation of nuclear phenomena (radioactivity, fission and fusion) Principle of equivalence and principle of general relativity	**KNOWLEDGE** Develop curiosity and aptitude for research, observation and reasoning skills He knows how to select information in a critical and conscious way Understands the supporting structures of the argumentative and demonstrative procedures of mathematics, also through the mastery of logical-formal language knows how to use them in particular in identifying and solving problems of various kinds **OPERATIONAL METHODOLOGY:** - Apply laws to solve simple problems - Acquire an autonomous, flexible and critical method of studyRelationship - Put data into relationship in order to understand and analyse the information - Develop group work abilities **LINGUISTIC-COMMUNICATIVE:** knowing how to use a specific language with clarity
3	Quantum mechanics	Black body radiation and Planck's hypothesis. The concept of quantum and the quantization of energy. Photoelectric effect. Bohr's model of the atom and interpretations of atomic spectra. De Broglie wavelength. Wave-particle dualism and the limits of the validity of the classical description.	**KNOWLEDGE** Develop curiosity and aptitude for research, observation and reasoning skills He knows how to select information in a critical and conscious way Understands the supporting structures of the argumentative and demonstrative procedures of mathematics, also through the mastery of logical-formal language knows how to use them in particular in identifying and solving problems of various kinds **OPERATIONAL METHODOLOGY:** - Apply laws to solve simple problems - Acquire an autonomous, flexible and critical method of studyRelationship - Put data into relationship in order to understand and analyse the information - Develop group work abilities **LINGUISTIC-COMMUNICATIVE:** knowing how to use a specific language with clarity -

		Diffraction and electron interference. The Heisenberg principle of indetermination	

Table 8: II. SS. "Carlo Alberto Dalla Chiesa" Physics Curriculum

Course: First Biennium
Students' age: 14-16
Science Lyceum
Subject: IT

Content			Competences
N.	General topic	Specific topic	
1	IT and Communication	Computer architecture and components • the concepts of hardware and software binary coding; • Von Neumann's ASCII and Unicode machine codes: CPU, memory, disks, bus and the main peripherals. Operating systems • operating system concept; • basic functionality and characteristics of the most common operating systems; • the concept of process as a running program • the basic mechanism of memory management and the main functionalities of the file systems. The tools for individual productivity Word processing: • characters, fonts; • paragraph formatting;	**KNOWLEDGE:** • Knowing how to use the computer to find, evaluate, store, produce, present and exchange information; • Knowing how to measure the complexity of a problem; • Be aware that the solution of problems is achieved through a continuous process of reuse of previous experiences. **LINGUISTIC-COMMUNICATIVE:** • Knowing how to describe the components of a computer using the specific terms of the computer language; • Knowing how to represent sequential, parallel and cooperative processes through graphic symbols; • Knowing how to communicate on the web through emoticons, acronyms, summaries, etc. in compliance with the netiquette; • Knowing how to express resolution procedures through algorithms, produce textual and graphic documentation relating to the software development phases. **METHODOLOGICAL-OPERATIONAL:** • Understand that spending more money does not mean having the best device for your needs; • Knowing that the operating system characterizes the usability of the Personal Computer and smartphone (referred to in the ECDL syllabus); • Knowing how to organize simple multimedia documents (referred to in the ECDL syllabus); • Knowing how to implement algorithms with different programming styles. **RELATIONAL:** • Respect the hardware and software resources of the laboratories, cooperate within the group in the search for study material; • Knowing how to interact with others, helping fellow students in difficulty during laboratory activities and analysis of context situations; • Knowing how to use IT networks and tools in research and disciplinary study activities within the classroom and study group

		• page formatting; • the insertion of images.	

Table 9: II.SS. "Carlo Alberto Dalla Chiesa" Physics Curriculum

Course: Second Biennium

Students' age: 16-18

Science Lyceum

Subject: IT

Content			Competences
N.	General topic	Specific topic	
1	ALGORITHMS IT AND COMMUNICATI ON	Programming, declarative and markup languages • Javascript language; • HTML language; • SQL language. Elements of logic • Propositions and logical connectives; • Tables of truth. Problem solving: from the algorithm to the program • From the problem to the algorithm; • Software design techniques; • General information on programming languages; • Structured programming language; • Testing and supporting documentation. The processing system • Hardware architecture; • Software. User interface and hypertext design • User interface guidelines; • Basic concepts of graphics; • Web design; • Creation of hypertext pages. Use and basic elements of Data Base • Fundamental concepts on the organization of a relational database • Creation and use of relational database objects. **Computer networks** • Internet and www; • Client / server and peer to peer models; **The digital society** •Privacy protection; • Software use licenses;	**KNOWLEDGE:** • Knowing how to measure the complexity of a problem; be aware that the solution of problems is achieved through a continuous process of reuse of previous experiences; • Knowing how to process one's digital representation both in an active context of facilitator / resolution of organizational complexities and in the individuality of a digital citizen. **LINGUISTIC-COMMUNICATIVE:** • Knowing how to express resolution procedures through algorithms, produce textual and graphic documentation relating to the software development phases; • Knowing how to represent the network structure through graphic and hypermedia models. **METHODOLOGICAL-OPERATIONAL:** • Knowing how to implement algorithms with different programming styles; • Knowing how to identify and apply project management methodologies and techniques; knowing how to design, create and publish simple web pages; • Knowing how to identify and apply techniques for the modeling and organization of the Databases, starting from the study of the problem. • Knowing how to create multimedia presentations for the presentation of an individual or group didactic study (referred to in the ECDL syllabus); • Knowing how to identify and deal with the threats associated with the use of information technologies, improving their ability to securely manage their data and the data of the organizations they work for (referred to in the ECDL syllabus). • Knowing how to safely manage their data saved on the PC, applying the appropriate strategy (referred to in the ECDL syllabus) **RELATIONAL**: • Knowing how to use IT networks and tools in study, research and disciplinary study activities within the classroom and study group. • Knowing how to participate in social networks with awareness.

		• Fundamentals on the protection of copyright.	**P.C.T.O.** • Skills for all types of sectors

ROMANIA

School in our country is *structured* as following:

- **lower secondary school: grades 5 to 8(ISCED level 2)**
- upper secondary school: grades 9 to 12 (ISCED level 3)
  - high school (liceu) – 4 years
  - vocational school (professional, or VET education)- 3 years(ISCED – International Standard Classification of Education)

The first two years of upper secondary education are compulsory. General upper secondary education is offered by the 'liceu', which is attended by about 75 % of pupils in upper secondary education.

Graduation system:

- High school studies end with the high school completion certificate
- Professional school studies end with thecertificate of professional competences access to university studies: the baccalaureate exam

Table 10: In Romania ScienceEducation (STEM) in upper secondary level (15 – 19 years olds), mathematics-informatics pathway is the following:

Informatics	Biology	Mathematics	ICT	Physics	Chemistry	Total
1/4	2/2	2/2	1/2	3/3	2/2	20
4/7	1/1	4/4	0/1	3/3	1/1	19

Table 11: In lower secondary level (11 – 14 years olds) we have the following display:

Informatics	Biology	Mathematics	ICT	Physics	Chemistry	Total
-	1/2	4	1	2	2	11

- ICT and Informatics education
- The evolution of the Romanian society is deeply influenced by the orientation towards the digital content. There are strategies and programs for students and long-life education for adults, e.g. ECDL (European Computer Driving License), IC3 (Internet and Computing Core Certification)
- Romania integrated the learning of ICT and Informatics into the national policies of modern curricula of education and professional training. Starting with 2010 the Baccalaureate exam includes the certificate of digital competence. Informatics is one of the school subjects to be chosen for Baccalaurate exam.
- ICT and Informatics education in the secondary and higher education systems
- The curriculum of each educational track (theoretical, technological, and vocational) includes, for every profile and specialization, one of the disciplines *ICT* or *Informatics* in every year of study. Teaching follows key competencies: digital competences, competences in mathematics and basic competences in sciences and technology.
- Informatics is taught in the theoretical track, for the Mathematics-Informatics profile - 1 hour/week in the 9th and 10th grades and 4 hours/week in the 11th and 12th grades. Special classes (called "intensive") teach 4 and 7 hours/week respectively.
- In lower secondary level Informatics is not taught, only ICT 1 hour/week.

GERMANY

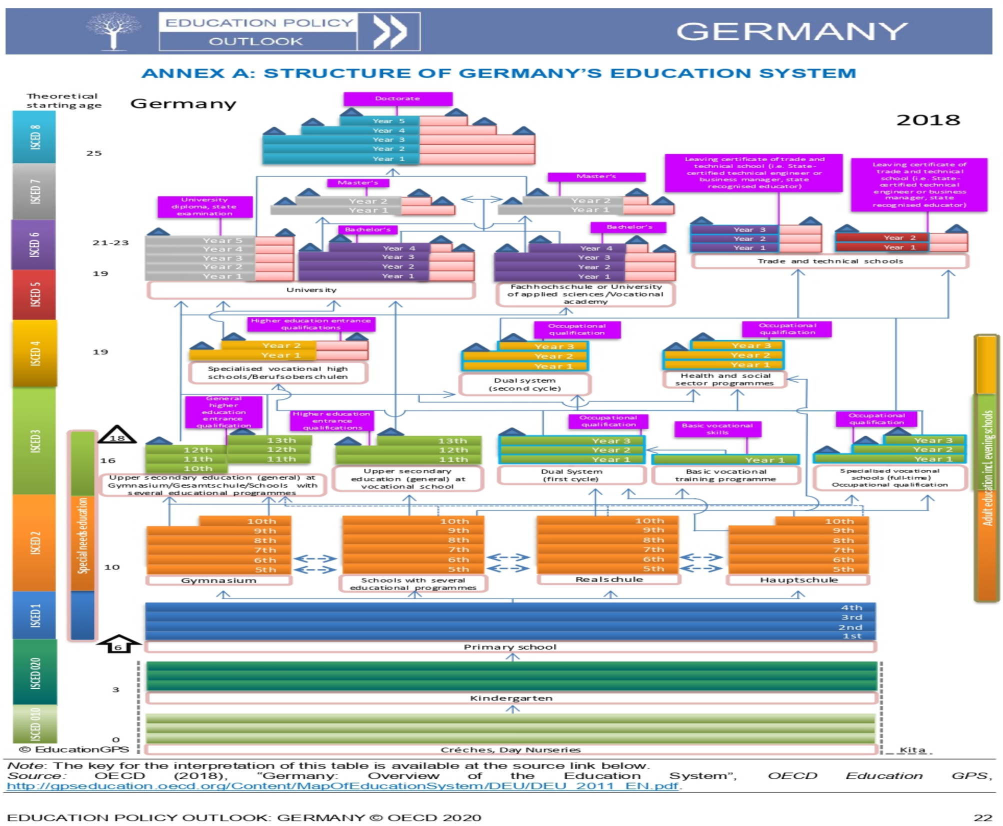
The quality of German education is world-renowned for a reason. It's well-organized and designed to be highly accessible to all students allowing to continue studying up to the university level regardless of a family's finances.

This article will give you an overview of the German standards of education, the organization of the school system, the subjects taught, grading systems, and more. Compulsory education in Germany is based on the rules and regulations of the Grundgesetz (which is the German basic or fundamental national law). The departments of Education, Cultural Affairs and Science come together to create comprehensive education guidelines, administrative regulations, organizations, and foundations.

German education standards are relatively pretty high. In fact, precisely because the German school system is so well structured and rigorous, it produces some of the most accomplished students in the world. In a 2015 OECD/PISA study, Germany ranked 11th in mathematics as well as in science.

Students are thoroughly tested and evaluated at each stage of schooling. If a student fails to achieve the required minimum grades in two or more classes, they have to repeat the whole year to ensure that they are always meeting the requirements to move up. Only 18% of students have to repeat the year once, and more than 50% of students report attending post-secondary education in Germany.

Chart 3. Education Policy Outlook Germany / OECD 2020



PRE-SCHOOL EDUCATION

Pre-school education isn't compulsory. It's up to 6 years old. It is aimed to improve children's language knowledge. General purpose is to develop the physical, mental and social abilities of children as a whole through play. Pre-school education is under the responsibility of the Ministry of Family.

— Kinderkrippe (Day-care center): 2 months - 3 years old, optional

— Kindergarten: 3-6 years old, optional, but provided by government for all

— It can be partially or fully funded depending on the local authority and the parents' income.

— All caregivers in kindergarten must have three years of certification.

PRIMARY EDUCATION

Primary education is compulsory. It starts at the age of 6 and lasts 4 or 6 years, depending on the states. Schooling rate is close to 100%. Its purpose is to develop imagination, abilities and socialization of the individual. General evaluation reports are given, report card is not. There is an effective guidance and recommendation letter. Mathematics lesson is taught every day. Subjects taught in German primary schools are German language, mathematics, general studies, foreign language, art, handicrafts/textile design, music, sports, and religion/ethics. They also teach intercultural, mint, media, health, musical-aesthetic, sustainable development, and values education. The curriculum is focused on German and Social Sciences, but the teacher determines it. Individual differences are respected. Children are directed to secondary schools in line with their abilities. The class teacher and the school principal decide which school students will attend according to their success in Mathematics, German and Social Studies.

SECONDARY EDUCATION TYPES

- Gymnasium: They are academic high schools requiring hard work that provide the university entrance qualification to the students. Its aim is to train students for higher schools and universities. Gymnasium curriculum includes German, mathematics, informatics & computer science, physics, chemistry, biology, geography, art, music, history, philosophy, civics / citizenship, social sciences, and several foreign languages. Those who pass the Abitur exam pass to higher education without taking another exam.

- Realschule: It is an academic program requiring less effort that allows the student to obtain a secondary school diploma that demonstrates good academic skills. The Realschule is providing a strong grounding in mathematics, modern languages, and technical fields. German and math lessons fill four periods each per week; a foreign language (usually English), geography, physical education, and fine arts for two periods each a week; and science and history for one period each.

- Hauptschule: It is a program for students who are considered to have limited academic competence and interests. In Hauptschule, German, mathematics, the natural and the social sciences, civic, religion, physical education, computer sciences and foreign languages are taught. At the end, a certificate of completion is given.

- Gesamtschule: It's an integrated version of hauptschule, realschule and gymnasium. They are multi-purpose schools that have become an alternative to the three-element school system. The central idea of the integrated Gesamtschule is to overcome social barriers by teaching all pupils together. That can be done in subjects that do not differ too much between the three traditional types of school, for example, in social studies or physical education. For subjects like German, foreign languages, and mathematics, there are courses offered at different levels. The kind of leaving certificate a student receives mainly depends on the levels of these courses. Therefore the assignments to the courses are very important to the students.

• Förderschule: It is the institution that undertakes the education of physically and mentally handicapped students.

ABITUR (HIGH SCHOOL GRADUATION EXAM)

The Abitur diploma program is also qualified as a German high school graduation exam. Students with this diploma can enter universities not only in Germany, but also in many European countries and the USA.

HIGHER EDUCATION

Universities and equivalent higher education institutions aim to train highly qualified young scientists.Higher education system in Germany, it is divided into three parts as:

1. Universities / Universitaet

2. Vocational Schools / Fachhochschule

3. the High School of Art / Kunsthochschule.

Universities in two forms, technical university and classical university, offer the backbone of higher education and the broadest alternatives for foreign students. Germany's universities are internationally recognized. In the academic ranking of world universities, six of the top 100 universities in the world are in Germany.

In PISA 2018, students in Germany performed above the OECD average, at 498 score points compared to 487. Germany's reading performance has improved on average by 3.3 score points across PISA cycles since 2000. According to OECD's 2020 EAG (Education At A Glance) Report,

On average, 46% of all upper secondary students enrol in VET programmes in Germany, a higher proportion than the OECD average of 42%. In 2019, 33% of 25-34 year-olds had a tertiary degree in Germany compared to 45% on average across OECD countries.

In Germany, in 2018, 25-64 year-olds with a tertiary degree with income from full-time, full-year employment earned 61% more than full-time, full-year workers with upper secondary education compared to 54% on average across OECD countries. In 2017, Germany invested a total of USD 13 529 per student on primary to tertiary institutions compared to USD 11 231 on average across OECD countries. This represents 4.2% of GDP, compared to 4.9% on average across OECD countries.

In 2018, 94% of 3-5 year-olds were enrolled in early childhood education and care programmes and primary education in Germany, compared to 88% on average across OECD countries. The German Educational System owes its success to the equality of opportunity it provides, and to the fact that it guides students from pre-school education to university from an early age in line with their abilities and achievements. Students involved in a good educational and cultural program in schools, they start life with analytical thinking, developed imagination, developed self-confidence, sportive and artistic skills.

Table 12: Here are the details of the rising statistics of the German education system according to OECD datas:

#	List of key indicators [1,2,3]	Germany	Average or total	Min OECD	Max OECD
	Background information				
	Economy				
1	GDP per capita, 2016, in equivalent USD converted using PPPs (OECD Statistics)	49 516	42 441	14 276	107 775
2	GDP growth, 2016 (OECD Statistics)	2.2%	1.8%	0.6%	6.6%
	Society				
3	Population density, inhab/km^2, 2017 (OECD Statistics)	234	37	3	517
4	Population aged less than 15 as a percentage of total population, 2018 (OECD Data)	13.5%	17.0%	12.2%	28.4%
5	Foreign-born population as a percentage of total population, 2018 or the most recent available year (OECD Data)	16.0%	14.4%	0.8%	47.6%
	Education outcomes				
6	Mean performance in reading (PISA 2018)	498	487	412	523
7	***Average three-year trend in performance across PISA assessments, by domain (PISA 2018)*** [4,5]				
	Reading performance	**3.3**	0.4	**-4.9**	**7.1**
	Mathematics performance	-0.1	-0.6	**-9.1**	**6.4**
	Science performance	**-3.6**	-1.9	**-10.7**	**6.4**
8	Enrolment rates of 3-year-olds in early childhood education and care, 2017 (EAG 2019)	91.2%	79.3%	2.4%	100%
9	Percentage of 25-64 year-olds whose highest level of attainment is lower secondary education, 2018 (EAG 2019)	9.7%	14.4%	0.8%	39.9%
10	***Educational attainment of the population aged 25-34 by type of attainment, 2018 or latest available***				
	At least upper secondary education, 2018 (EAG 2019)	87.0%	85.4%	50.1%	97.8%
	Tertiary education, 2018 (EAG 2019)	32.3%	44.3%	23.4%	69.6%
	Vocational upper secondary or post-secondary non-tertiary education, 2018 (EAG database 2020)	47.2%	24.5%	1.8%	50.1%
11	***Unemployment rates of 25-34 year-olds by educational attainment, 2018 (EAG 2019)***				
	Below upper secondary	13.2%	13.7%	3.0%	37.3%
	Upper secondary and post-secondary non-tertiary	3.4%	7.3%	2.5%	25.1%
	Tertiary education	2.8%	5.5%	1.7%	23.2%
	Students: Raising outcomes				
	Policy lever 1: Equity and quality				
12	First age of selection in the education system (PISA 2018)	10	14	10	16
13	***Students performing at the highest or lowest levels in reading (%) (PISA 2018)***				
	Students performing below Level 2	20.7%	22.6%	11.1%	49.9%
	Students performing at Level 5 or above	11.3%	8.7%	0.8%	15.0%
14	Percentage of students in schools where students are grouped by ability into different classes for all subjects, PISA 2015	8.0%	7.8%	0.0%	56.1%
15	Percentage of students whose parents reported that the schooling available in their area includes two or more other schools, PISA 2015	37.4%	36.8%	20.4%	56.9%

#	List of key indicators[1,2,3]	Germany	Average or total	Min OECD	Max OECD
16	Percentage of students reporting that they have repeated at least a grade in primary, lower secondary or upper secondary schools (PISA 2015)	18.1%	11.3%	0.0%	42.6%
17	Percentage of variance in reading performance in PISA test explained by ESCS (PISA 2018)[4]	17.2%	12.0%	6.2%	19.1%
18	Score difference in reading performance in PISA between non-immigrant and immigrant students AFTER adjusting for socio-economic status (PISA 2018)[4]	**-17**	**-24**	**-80**	**16**
19	Score difference between girls and boys in reading (PISA 2018)[4]	**26**	**30**	**10**	**52**
Policy lever 2: Preparing students for the future					
20	Mean proficiency in literacy among adults aged 16-64 on a scale of 500 (Survey of Adult Skills, PIAAC, 2012)	269.8	267.7	220.1	296.2
21	Difference in literacy scores between younger (25-34) and older (55-65) adults AFTER accounting for age, gender, education, immigrant and language background and parents' educational attainment (Survey of Adult Skills, PIAAC, 2012).	26.8	15.6	-8.3	37.6
22	***Share of students in upper secondary education in 2017 following:***				
	General programmes (OECD Stat - INES 2020)	54.4%	58.1%	27.6%	100.0%
	Vocational programmes (OECD Stat - INES 2020)	45.6%	43.1%	9.0%	72.4%
	Combined school and work-based programmes (OECD Stat - INES 2020)	39.8%	18.3%	1.0%	58.0%
23	First-time graduation rates from tertiary education, 2017 (Below the age of 30, excluding mobile students / OECD Stat - INES 2020)	32.9%	36.6%	10.1%	49.9%
24	Percentage of 18-24 year-olds not in education, employment or training, 2018 (EAG 2019)	9.6%	14.3%	5.9%	29.8%
Institutions: Improving schools					
Policy lever 3: School improvement					
25	***The Learning Environment - PISA 2018***				
	Mean index of teacher support in language-of-instruction lessons	-0.24	0.01	-0.61	0.47
	Mean index of disciplinary climate	0.04	0.04	-0.34	1.07
	Mean index of students' sense of belonging[7]	0.28	0.00	-0.28	0.46
26	Percentage of teachers in lower secondary education aged 50 years old or more, 2017 (EAG 2019)	45.9%	37.0%	6.3%	54.2%
27	***Number of teaching hours per year in public institutions by education level, 2018 (EAG 2019)*** [8]				
	Primary education	800	783	561	1063
	Lower secondary education, general programmes	744	709	481	1063
28	Ratio of actual teachers' salaries to earnings for full-time, full-year adult workers with tertiary education, lower secondary education, general programmes, 2016 (EAG 2019)	1.00	0.88	0.64	1.40
29	Proportion of teachers who believe the teaching profession is valued in society (TALIS 2018)	NP	25.8%	4.5%	67.0%
30	Proportion of teachers who would become a teacher again if they could choose (TALIS 2018)	NP	75.6%	54.9%	92.2%

Framework Curriculum 1-10 compact

An overview of the subjects and content taught in Berlin[1]

When do the subjects start being offered?

Table 13: Subject start being offered[2]

Standard subjects

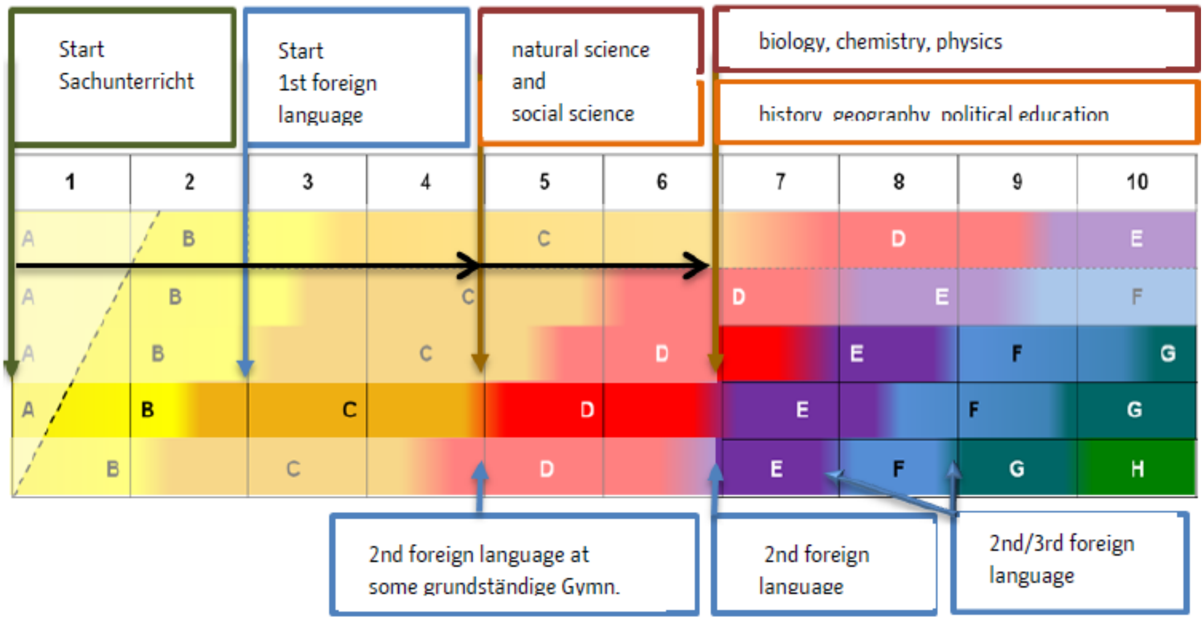
Grade level	1	2	3	4	5	6	7	8	9	10
German										
Mathematics										
1st foreign language (English/French) [1)]										
2nd foreign language [2) 3)]										
*Sachunterricht**										
Social Science 5/6										
Geography										
History										
Political Education										
Ethics										
Natural Science 5/6										
Biology							v	v		
Physics							v	v		
Chemistry							v	v		
Information and Communications Technology (ICT)							v	v		
Wirtschaft-Arbeit-Technik (WAT - Economy-Work-Technology) at ISS										
Art										
Music										
Sports										

*Subject taught at primary school familiarising pupils with scientific and technical phenomena and with social, economic and historical aspects of their own area

1) Other languages are offered as early as grade 1 at the *Europaschulen* (State Europe School Berlin) and in school pilot projects.
2) Learning a second foreign language is mandatory at *Gymnasien* (university-track high schools).
3) At some *grundständige Gymnasien* (*Gymnasien* that start in grade 5), the second foreign language already begins in grade 5 or 6.

[1] http://bildungsserver.berlin-brandenburg.de/unterricht/rahmenlehrplaene/neuer-rahmenlehrplan-fuer-die-jahrgangsstufen-1-10/amtliche-fassung/
[2] https://www.berlin.de/sen/bildung/unterricht/faecher-rahmenlehrplaene/rahmenlehrplaene/

Table 14: It shows that within one grade students can be learning for the same subject at different levels and that the transition from one level to the next is fluid.



Physics is an essential basis for understanding natural phenomena and explaining and assessing technical systems and developments. Physical findings are used in technology, for example, to build devices and sys-tems to transmit information, to convert energy into the form needed and transport it to the consumer. Nature itself often serves as a model for technical solutions.

The content and methods students learn in Physics class teaches them to approach tasks and problems from a scientific perspective. Physics examines a range of natural phenomena and applies typical methods of thinking and working that are associated, for example, with activities like experimenting, observing and measuring.

Technical progress, however, also poses risks that have to be identified, evaluated and overcome because they influence political decisions. Basic education in the natural sciences is therefore indispensable to stu-dents' participation in society.

The procedure in physics lessons should be designed from the outset in such a way that young people are invited, encouraged and inspired by physics lessons to open up the world from a physical point of view.

This approach to physics should be based on selected, interesting phenomena and experiments in thermodynamics. Important activities that the learners have already become acquainted with in the topic From the senses to measurement in the subject Natural Sciences 5/6 are taken up and deepened, in particular the observation and description of physical phenomena and the explanation of these phenomena using simple thought models. In addition, the use of physical quantities should be practiced and deepened in this subject area. In this subject area the learners learn that particle ideas are required to explain thermodynamic phenomena. Care must be taken to ensure that verbal and written descriptions and explanations are carefully distinguished between model and reality. The introduction of the physical quantity density can be integrated, for example by examining the expansion of air when the temperature rises.

What competencies do students acquire in the subject?

Technical knowledge

Students acquire competencies to deal with technical questions and content. They work on the content on the basis of interrelated basic concepts. The **basic concepts of** "matter", "system", "energy" and "reciprocity" describe and structure scientific content for the students. They form the basis of systematic knowledge building for the students from a technical and real-world perspective at the same time.

Knowledge acquisition

Students observe and describe phenomena, formulate questions and propose hypotheses. They plan their approach and learn relevant information using investigative and research methods. They apply technical and general scientific working practices in the process: tracing back to and classifying according to what they already know, systematising, comparing, proposing hypotheses, experimenting.

Communication

The ability to communicate based on fact and appropriate to the target audience using suitable media is an essential part of basic scientific education. This requires the right combination of everyday language and technical jargon.

Evaluation

By selecting appropriate content, students can recognise links between the individual scientific disciplines in everyday life, the environment and science. Students explore topics relevant to society from different per-spectives and learn that problem-solving depends on value judgements. They learn to differentiate between biological, chemical and physical facts, hypothetical and non-scientific statements in texts and images and are aware of the limits of the scientific perspective.

What topics and content are taught in the subject?

Double grade level 7/8

1. Thermal behaviour of bodies
2. Reciprocity and force
3. Mechanical energy and work
4. Thermal energy and heat

Movable topics - double grade level 7/8 or 9/10

5. Electric power and electric charge
6. Electric current, voltage, resistance and power Double grade level 9/10
7. Uniform and accelerated movements
8. Force and acceleration
9. Magnetic fields and electromagnetic induction
10. Radioactivity and nuclear physics
11. Energy conversions in nature and engineering
12. Mechanical oscillations and waves
13. Optical devices

1 Thermal behavior of bodies
The approach in physics lessons should be designed from the outset in such a way that thephysics lessons invite, encourage and inspire young people to explore the world from a physical point of view. This approach to physics should be based on selected, interesting phenomena and experiments in thermodynamics. Important activities that the learners have already become acquainted with in the topic From the senses to measurement in the subject Natural Sciences 5/6 are taken up and deepened, in particular the observation and description of physical phenomena and the explanation of these phenomena using simple thought models.In addition, the use of physical quantities should be practiced and deepened in this subject area. In this subject area, the learners learn that particle ideas are required to explain thermodynamic phenomena. Care must be taken to ensure that verbal and written descriptions and explanations are carefully distinguished between model and reality. The introduction of the physical quantity density can be integrated, for example by examining theexpansion of air when the temperature rises.

Content	Experiments / investigations
- Subject areas of physics - Change in length of solid bodies when thetemperature changes (qualitative) - Change in volume of liquids and gaseswith temperature change (qualitative) - Relationship between mass and volume ofa body - Density as a physical quantity - Relationship between pressure and temperature of a gas at constant volume - Interpretation of the pressure in gases withthe help of simple particle ideas - Description of the physical states in theparticle model	- Expansion of solid bodies, e.g. B. Metalpipe or wire when the temperature rises - Expansion of liquids depending on thetemperature change and the substance - experimental determination of density - Measurement of air pressure

References to the basic concepts	
matter	**The thermal behavior of bodies depends on the substance. Particle ideas are used to explain thermodynamic phenomena. Substances can have different physical states depending on thetemperature.**

Possible contexts	Technical terms
- Dangers due to changes in the length ofstructures and how to eliminate them - Fire alarm and sprinkler system for fireprotection - Up high in a hot air balloon - Observe and describe weatherphenomena	- temperature - temperature difference - Celsius and Kelvin scales - particle model - bimetal strips - density - air pressure - Brownian motion

Examples of differentiation options
- Calculation of changes in length in the event of temperature changes - Different depth of the interpretation of processes with the particle model - Independence in formulating assumptions - Design and scope of the experimental tasks and the experiment instructions

2 Reciprocity and force	
The concept of force is introduced based on interactions between bodies in everydaysituations. A distinction is made between different types: plastic and elastic deformation as well as changes in the direction and speed of movements. In the classroom it should be made clear that when dealing with forces, idealizations are often made to simplify matters, e.g. B. by neglecting friction. Since the terms energy and work are only introduced later, care must be taken that the meanings of the terms force, energy and work are not mixed up when explaining the interactions between bodies.	
Content	**Experiments / investigations**
- Force as a physical quantity - Kraftpfeil model - Force as an interaction between two bodies when bodies change shape andmovement - weight force (qualitative and quantitative) - Hooke's law - Force measurement	- Relationship between force and changein length of a helical spring - Measuring forces using a spring forcemeter or force sensor
References to the basic concepts	
interaction	Description of interactions between two bodies using the quantity force
matter	Difference between mass and weight Properties of materialssuch as deformability and elasticity
Possible contexts	**Technical terms**
- Forces drive vehicles, e.g. B. whencycling - Forces in sport, e.g. B. Interactions insoccer, weightlifting, pole vaulting and bungee jumping	- plastic and elastic deformation - interaction -Force - Balance of forces -Dimensions - weight force
Examples of differentiation options	
- Evaluation of the experiments and description of the relationship between force and change in length at different levels (qualitative, description using diagrams, descriptionusing the spring constant) - Investigation of the relationship between the force and change in length of a rubber band	

3 Mechanical energy and work

In this subject area, the term energy and its connection to mechanical work is introduced. Using the example of potential energy, amounts of energy are calculated for the first time. The other forms of energy are treated qualitatively, whereby non-mechanical forms ofenergy are included without going into any further detail here. It is particularly important to carefully differentiate between the terms work, energy and performance. When describing energy conversions, the term system is introduced and applied.

Inhalte	Experimente/Untersuchungen
- Energy concept, forms of energy (qualitative), potential energy (quantitative) - mechanical work - Types of mechanical work - Golden rule of mechanics - Relationships between work, energy andperformance - Conservation of energy law - Energy considerations in simple systemsincluding energy schemes	- Investigations into the golden rule ofmechanics - experimental determinations of mechanical work and mechanical power

References to the basic concepts

energy	Energy is a conservation quantity. Change of energy through work
system	Consideration of closed systems when describing energyconversions

Possible contexts	Technical terms
- Ramps for wheelchair users and otherforce-converting devices in everyday life - energy conversions in power plants, z. B. in a pumped storage plant - Opportunities to save energy - crash tests - people as energy converters, e.g. B. insports - levers on the human body	- mechanical work - lifting work - kinetic and potential energy - chemical energy - thermal energy - radiant energy - mechanical performance - closed system

Examples of differentiation options

- Formulation and application of the Golden Rule at different levels (qualitative, anti-proportionality of force and path)
- Application of the golden rule of mechanics to various force-converting devices
- Efficiency considerations

4. Thermal energy and heat	
In the everyday ideas of the students, warmth is often understood as something material. The example of thermal radiation shows that the transfer of heat is not bound to a substance. Since the treatment of the transfer of heat offers a variety of points of contactwith the experiences of the students, the similarities and differences of the three types of transfer heat conduction, heat flow and heat radiation can be worked out and highlighted through practical studies.	
Content	**Experiments / investigations**
- Relationship between thermal energy andheat - Temperature equalization of bodies with different temperatures - Heat of fusion, heat of evaporation, cooling by evaporation - Changes in the state of aggregation andtheir interpretation with the help of simple particle ideas - Heat conduction, heat flow, heat radiation - Heat conduction in the particle model	- Investigation of the temperature profile during the heat transfer between two amounts of water with different initial temperatures - Investigation of the heat transfer through various substances

References to the basic concepts	
matter	There are good and bad heat conductors. Heat conduction can bedescribed in the particle model.
System	The description of the heat absorption and release of bodies requires the consideration of systems. To simplify matters, closed systems are often considered.
energy	The energy is retained during thermodynamic processes. As a processvariable, heat describes the process of transferring energy.

Possible contexts	Technical terms
- Influence of ocean currents on the climate - Formation of land and sea wind - Heat balance of animals (polar bear, fennec) - Heat supply in the school and evaluationof own user behavior - Zero energy house - an energy savinghouse of the future?	-thermal energy - warmth - Melting, solidifying, boiling, evaporation, condensation, evaporation, melting temperature, boiling temperature - heat conduction - heat flow - thermal radiation

Examples of differentiation options
- Different depth of the interpretation of the phenomena with the particle model - Description and explanation of heat transfers in different complexities (heating in a room,heating system in a house, energy flows in an energy-saving house)

5 Electric Current and Electric Charge	
The pupils get to know examples of electrical circuits and sources of electrical energy,although the physical quantities of current and voltage are not yet discussed here. Theeffects of electric current are introduced with the help of simple electrical circuits. The introduction of the model of electric field lines enables the explanation of interactions between electrically charged bodies and thus the development of a model for the electricalconduction process in metals. Suitable analogues can be used to explain electrical conduction processes in circuits, e.g. B.the water cycle model.	
Content	**Experiments / investigations**
- Simple circuit as a series connection of anelectrical energy source, a switch and an energy converter - Attraction and repulsion betweenelectrically charged bodies - Model of the electric field line - Model for electrical conduction processes inmetals - electrical energy sources - Electric current as a moving electric charge - Effects of electric current - Representation of simple electrical circuitsusing circuit symbols - Series and parallel connection	- Illustration of the effects of the electriccurrent - Proof of charge using an electroscope - Construction of simple circuits
References to the basic concepts	
matter	Existence and causes of electric fields Electriccurrent as the movement of charge carriers
interaction	Forces in electric fields
energy	Sources and conversion of electrical energy
system	electrical circuit as a system

Possible contexts	Technical terms
- Effects of electric current in householdappliances, e.g. B. How the kettle and doorbell work - AND-OR circuit in practice, e.g. B. forsafety measures for electrical devices - Electrostatic charges in everyday life - Thunderstorm - From the Galvanis frog leg experiment tothe modern battery - Voltage sources for traveling, e.g. B.Batteries, solar cells, hand generators	-electric charge - electron -electric field - electric field line -electrical current
Examples of differentiation options	
- Complexity of the circuits to be examined - Working with the field line model at different levels	

6 Electric current, voltage, resistance and power

With the introduction of the physical quantity electrical current strength, the idea of the electron cycle is deepened and described quantitatively. With the introduction of the physicalquantity electrical voltage as the drive for electrical current, the sources of electrical energy from topic 5 are taken up and deepened. The clear explanation of the physical quantity voltage can be made with the help of analogies to the water cycle model.
When using measuring devices, particular care must be taken to ensure that they are usedcorrectly and handled with care.

From the experimentally determined relationship between current strength and voltage, thephysical quantity of electrical resistance is developed, which is described by Ohm's law forthe case of a proportional dependence of current strength and voltage.
The electrical resistance as an energy converter in a circuit leads to the consideration ofelectrical energy and electrical power.

Content	Experiments / investigations
Current strength as a physical quantity Voltage as a physical quantity and drive ofelectrical current Ohm's law electrical resistance as a physical quantityand electrical component electrical resistance as a function oftemperature Current and voltage in series and parallelconnection Law of Resistance electrical power and energy as physicalquantities	Voltage measurements at different voltage sources Current measurements in different devices Recording of a current-voltage relationship of a component Determination of the electrical power of a device

References to the basic concepts

matter	The strength of currents in matter can be influenced by resistances.The resistance depends on the material.
System	**Circuits as systems**
Energy	Energy flows in electrical circuits Electrical power and electrical energy can be determined indirectly using the physical quantities current, voltage and time.

Possible contexts	Technical terms
Resistors as sensors Series resistors for light emitting diodes Technical resistances and theirminiaturization in computer and communication technology Development of electrical light sources, e.g. B. Incandescent lamp, energy saving lamp,LED Electric current hazards Cable fires in the event of overload	electric current electrical voltage electrical resistance specific electrical resistance electrical power electrical power

Examples of differentiation options

Independence in planning, carrying out and evaluating experiments
Requirements for the processing of mathematical-physical tasks
Series connection of solar cells
Investigation of series and parallel connections voltage divider circuit

7 Uniform and accelerated movements	
Based on everyday experiences of the relativity of movements, these are described and compared. In the subject area, an understanding must be developed for the fact that uniform and uniformly accelerated movements represent model-like simplifications of mostly significantly more complicated sequences of movements. Movements in everyday life offer a variety of starting points for experimental as well as mathematical-physical investigations. Problems relating to the determination of braking and stopping distances provide referencesto traffic education.	
Content	**Experiments / investigations**
- Movement, types of movement andreference system - Differentiation between current andaverage speed - Description of movements using theparameters speed and acceleration - Laws of motion of uniform and uniformlyaccelerated motion and associated diagrams - Interpretation of movements using s (t) andv (t) diagrams - Free fall, determination of the accelerationof the fall - horizontal throw as a compoundmovement (qualitative) - random and systematic errors	- Investigation of the dependence s (t) for uniform movements, e.g. B. using the air cushion track, a rising air bubble or a modelrailway on a straight line - Investigation of the dependency s (t) foruniformly accelerated movements, z. B. using the air cushion track or motionsensors - Investigation of falling movements
References to the basic concepts	
System	The description of movements depends on a selected referencesystem. Assignment of real movements to movement types

Possible contexts	Technical terms
- Road safety, e.g. B. Safety distances, overtaking maneuvers, braking distances,speed controls - Movements of an S-Bahn - movements of an aircraft, e.g. B. Take-off,flight, speed measurement - braking distances, e.g. B. in space travel, inshipping - A world without friction - tachograph - Galileo versus Aristotle"	- reference system - uniform rectilinear movement - Current speed, average speed - acceleration - Response time, response path - braking and stopping distance - acceleration due to gravity
Examples of differentiation options	
- Complexity of the movements under consideration, e.g. B. Approaching an S-Bahn, acomplete journey of an S-Bahn between two stations - Extent of the simplifications to be made, e.g. B. Consideration of initial conditions, unevenaccelerations - Degree of mathematization, e.g. B. Sign of speed and acceleration - Complexity of the diagrams to be evaluated - Recognize and evaluate the influences of errors in experiments	

8 Force and acceleration		
The historical development of the views of important philosophers and natural scientists on the cause of movements lead to the current concept of force and Newton's axioms. These are not only to be seen as the cornerstone of dynamics, but can also be linked to everyday experience in a variety of practical ways. When solving problems by applying the basic lawof mechanics, the importance of the force as the resultant of all acting forces and the importance of the mass as the entire accelerated mass must be pointed out. Furthermore, the interaction of bodies due to friction will be discussed on the basis ofvarious experiments. When solving problems, the different meanings of interaction and balance of forces are deepened and mathematically advanced.		
Content		**Experiments / investigations**
- law of inertia - law of interaction - Basic law of dynamics - Decomposition and addition of forces insimple examples - Problem solving using Newton's Basic Law - Static friction, sliding friction and rollingfriction (qualitative) - Radial force as the cause of a circularmotion (qualitative) - Drag force		- Attempts at indolence - Attempts at friction - quantitative studies on the fundamental law of dynamics, e.g. B. using the air track, acceleration or force sensors
References to the basic concepts		
matter	Shape and surface properties have an influence on the air resistance ofa moving body.	
interaction	With the three Newtonian laws, motion sequences can be explainedand predicted.	
Possible contexts		**Technical terms**
- Analysis of crash tests and safetyprecautions in vehicles - Forces on vehicles, e.g. B. Bicycle, comparison of different cars and trucks,measures to reduce the drag coefficient - Ride in an elevator, soapbox races - Movement of a parachutist		- indolence - interaction - frictional force - resulting force, force decomposition - circular motion - radial force
Examples of differentiation options		
- Downhill force and normal force, investigations into the decomposition of forces on the inclined plane, e.g. B. Determination of coefficient of friction		

9 Magnetic fields and electromagnetic induction
The students know from topic 5 that one effect of the electric current is magnetism. The properties of electromagnets and permanent magnets are compared. The elementary magnet model is introduced to explain permanent magnetism; electromagnetism is explained as a property of electrical current. The field line model enables the interaction to be explained. Understanding the interaction of current-carrying conductors and magnetic fields and electromagnetic induction enables the explanation of important electrical devices, such as B.electric motor and generator as well as microphone and loudspeaker.

Content	Experiments / investigations
Permanent magnets and electromagnets Elementary magnet model Model of the magnetic field lines Comparison of electric and magnetic fields Forces on current-carrying conductors inthe magnetic field Structure and function of the electric motor Law of induction (qualitative) Generating an alternating voltage with agenerator Structure, function and voltage translationof an unloaded transformer	Forces on live conductors Proof of induction voltages Voltage ratio on the transformer

References to the basic concepts	
matter	An iron core strengthens the magnetic field inside a current-carryingcoil.
interaction	Explanation of the creation of tensions through the interaction ofmagnetic field and induction coil
System	Consideration of complex technical devices, such as. Engine andgenerator
Energy	Induction as energy conversion and energy transfer

Possible contexts	Technical terms
-Earth's magnetic field -Wind power plant as a generator -Regenerative braking in electric or hybridvehicles: electric motor, generator -Record and generate sound with amicrophone or loudspeaker -Information storage hard drive	magnetic field electric motor electromagnetic induction induction voltage AC voltage generator transformer

Examples of differentiation options
- Inclusion of various applications of magnetic fields in technology, z. B. magnetic memory, magnetic stirring, magnetic sensors The description or explanation of the induction processes is possible at different levels. eddy currents

10 Radioactivity and Nuclear Physics	
The aim of this topic is that the learners get to know the phenomenon of radioactivity. Technical and medical applications of nuclear physics are particularly suitable for developingassessment skills. In this subject area, the learners acquire basic knowledge about the structure of the matter. The core-shell model known from chemistry lessons is used for this purpose. Changes in theatomic nucleus lead to the emission of ionizing radiation. These processes are described by means of statistical laws.	

Content	Experiments / investigations
- Types of natural radioactive radiation - absorption capacity (qualitative) - ionizing capacity - radioactive radiation from the atomic nucleus - Activity as a physical quantity - half-life - radioactive radiation in our environment - biological effects of radioactive radiation (qualitative) - nuclear fission	- Evidence of natural radioactive radiation - Real experiment or model experiment on radioactive decay, e.g. beer foam experiment, computer simulation

References to the basic concepts	
matter	Structure of matter from electrons, protons and neutronsRadiation as matter
interaction	Effects of radioactive radiation

Possible contexts	Technical terms
- Natural radioactivity - Applications of radioactive radiation in medicine - Nuclear power plants as a contribution to climate protection? - Nuclear weapons - responsibility of science - Final storage of radioactive waste as a social challenge	- radioactivity - stable and unstable atomic nucleus - isotope - α, β, γ radiation - ionizing radiation - nuclear disintegration - half-life - nuclear fission

Examples of differentiation options
- different depths of the description of the radioactive decay, e.g. B. word equations, decay equations, decay series - nuclear fusion

11 Energy conversions in nature and technology	
In this subject area, the students take up knowledge from the subject areas 3.3, 3.4 and 3.6 and deepen their knowledge through quantitative considerations, e.g. B. in the calculation ofenergy conversions and efficiencies. The subject area offers a variety of opportunities to address more complex issues and to linkknowledge from different subject areas, also beyond the subject of physics.	
Content	**Experiments / investigations**
- Energy conversions and energy transfers - Calculation of potential and kineticenergies - thermal power of a heat source - Calculation of heat, specific heat capacity - Efficiency and energy flow schemes forenergy conversions - Problem solving through quantitativeenergy considerations	- Dependencies of the heat on the temperature change, the mass and thesubstance - Determination of the efficiency of energyconversions, e.g. B. when heating water with the help of a kettle
References to the basic concepts	
Energy	Energy transfers and conversions are essential for all natural andtechnical processes. For the use of energy, the origin of the energy, the efficiency of the energyconversion and the effects must be taken into account. Quantitative considerations of energy are an essential prerequisite for thecareful handling and sensible use of energy.
System	The consideration of energy transfers and transformations requirethe definition of clearly defined systems.

Possible contexts	Technical terms
- Securing a sustainable energy supply inthe future - Energetic considerations on the effect of awrecking ball - Energy from the sun - Thermal power plants and their impact onclimate change - Solar, wind, hydro and thermal powerplants in comparison - Saving energy in the household - Storage of energy, e.g. B. in a pumpedstorage plant - Energy conversions in the human body	- potential energy - kinetic energy - thermal performance - Heat as a physical quantity - specific heat capacity - efficiency - open and closed systems
Examples of differentiation options	
- Scope and complexity of the quantitative energy considerations - global warming and energy generation - Transmission of electrical energy in power networks - Determination of the solar constant	

12 Mechanical vibrations and waves	
Mechanical vibrations are represented as a form of movement. Their periodic course can be explained by the coupling forces of the oscillatory system. In particular, the parameters of mechanical vibration should be investigated experimentally in a variety of ways. The equations for the period of the thread pendulum and spring oscillator enable quantitative comparisons with your own measurement results. Building on the everyday phenomenon of water waves, the parameters of mechanical waves as well as the phenomena of reflection, refraction, diffraction and superimposition can be illustrated in a practice-oriented manner.	
Content	**Experiments / investigations**
parameters of a harmonic oscillation Representation of harmonic oscillations indiagrams damping of vibrations Energy conversions in a thread pendulumor a spring oscillator response Characteristics of mechanical shafts Representation of mechanical waves indiagrams reflection and refraction Diffraction and interference of mechanicalwaves	parameters of a harmonic oscillation Representation of harmonic oscillations indiagrams damping of vibrations Energy conversions in a thread pendulumor a spring oscillator response Characteristics of mechanical shafts Representation of mechanical waves indiagrams reflection and refraction Diffraction and interference of mechanicalwaves

References to the basic concepts	
System	A mechanical vibration is caused by a disturbance in a vibratorysystem.
Materie	The propagation of a mechanical wave is explained by coupling forcesbetween the particles of matter. The speed of propagation depends onthe properties of the matter. The shape and material of springs have an influence on the period duration of spring oscillators.
Energie	Vibrations can be described by periodic energy conversions.A wave transmits energy without transporting matter.
interaction	The rest position is not an expression of an interaction, but anequilibrium of forces.

Possible contexts	Technical terms
Shock absorbers on the car effects of resonance effects, e.g. the collapse of the Tacoma NarrowsBridge earthquake waves, tsunami, z. B. possibleadvance warning times, earthquake-proof construction musical instruments, e.g. B. Sound generation, sound propagation, frequencyanalysis, acoustics of rooms Sea waves breaking on the beach	Amplitude, elongation, frequency,period duration rest position response Longitudinal shaft, transverse shaft wavelength speed of propagation reflection and refraction diffraction interference

Examples of differentiation options
Restoring forces in a spring oscillator and a thread pendulum Equation for calculating the period Qualitative or quantitative description of the diffraction and superposition of waves

https://bildungsserver.berlin-brandenburg.de/neuer-rlp-gymnasiale-oberstufe/anhoerung-zum-entwurf-des-rahmenlehrplans-fuer-die-gymnasiale-oberstufe-biologie-chemie-und-physik

13 Optical devices	
The phenomenon of light can be investigated using different methods and explained using different models. In this subject area, knowledge about the light beam model from natural sciences 5/6 is linked. It is applied to various everyday optical phenomena and to understanding the function of optical devices.	
Content	**Experiments / investigations**
- Light beam model - Speed of Light - Beam path in selected optical devices - Law of reflection and refraction - total reflection - Image formation with a converging lens - Image scale and lens equation - Refraction of monochrome light at theprism - Decomposition of white light at the prism,spectrum of light - colored pictures by adding the basiccolors red, green, blue, e.g. B. on thescreen or camera	- quantitative investigation of reflectionand refraction of light - Investigations on the lens equation - Color decomposition on a prism

References to the basic concepts	
matter	The reflection and refraction of light depend on the surface propertiesand the material of the body.
interaction	Interaction of the light with the obstacles as the cause of reflection,refraction
System	Light source, obstacle and detection device (screen or similar) as thewhole to be considered

Possible contexts	**Technical terms**
- Optical lenses against farsightedness andshort-sightedness - phenomena in nature, e.g. B. rainbows,mirages, z. B. Fata Morgana, - Light guides in technology - Image creation in a camera - Field of view of a diver	- reflection - refraction - total reflection - real and virtual images - focus - Focal, object and image distance - concave, convex - Spectral colors

Examples of differentiation options
- Law of refraction in different levels (qualitative, diagram, equation) - Image creation in other optical instruments, e.g. B. in the Kepler telescope and in the microscope - Diffraction and interference of light (interpretation with the wave model)

3- KEY COMPETENCIES AND SKILLS

TURKEY

Key competences are the defined eight competences that each individual is supposed to achieve within the scope of life-long learning. The key competences are defined in the concerned framework as follows (TQF, 2015, p. 23-24):

1) *Communication in the mother tongue*
2) *Communication in foreign languages*
3) *Mathematical competence and key competences in science/technology:* Competence in science refers to the ability and willingness to use the body of knowledge and methodology regarding the explanation of the natural world, in order to identify questions and to draw evidence-based conclusions. Competence in technology is viewed as the application of that knowledge and methodology in response to perceived human wants or needs. Competence in science and technology involves an understanding of the changes caused by human activity and responsibility as an individual citizen.
   Mathematical competence is the ability to develop and apply mathematical thinking in order to solve a range of problems in everyday situations. Building on a sound mastery of numeracy, the emphasis is on process and activity, as well as knowledge. Mathematical competence involves, to different degrees, the ability and willingness to use mathematical modes of thought (logical and spatial thinking) and presentation (formulas, models, constructs, graphs, charts)
4) *Digital competence:* Digital competence involves the confident and critical use of Information Society Technologies (ISTs) for work, daily life and communication. It is underpinned by basic skills in ICT: the use of computers to retrieve, assess, store, produce, present and exchange information, and to communicate and participate in collaborative networks via the Internet.
5) *Learning to learn:* 'Learning to learn' is the ability to pursue and persist in learning, to organise one's own learning, including through effective management of time and information, both individually and in groups. This competence includes awareness of one's learning process and needs, identifying available opportunities, and the ability to overcome obstacles in order to learn successfully. This competence means gaining, processing and assimilating new knowledge and skills as well as seeking and making use of guidance. Learning to learn engages learners to build on prior learning and life experiences in order to use and apply knowledge and skills in a variety of contexts: at home, at work, in education and training
6) *Social and civic competences:* These include personal, interpersonal and intercultural competence and cover all forms of behaviour that equip individuals to participate in an effective and constructive way in social and working life, and particularly in increasingly diverse societies, and to resolve conflict where necessary.
7) *Sense of initiative and entrepreneurship:* Sense of initiative and entrepreneurship refers to an individual's ability to turn ideas into action. It includes creativity, innovation and risk-taking, as well as the ability to plan and manage projects in order to achieve objectives. This supports individuals, not only in their everyday lives at home and in society, but also in the workplace in being aware of the context of their work and being able to seize opportunities, and is a foundation for more specific skills

   and knowledge needed by those establishing or contributing to social or commercial activity

8) *Cultural awareness and expression:* Appreciation of the importance of the creative expression of ideas, experiences and emotions in a range of media, including music, performing arts, literature, and the visual arts.

All key competences are interrelated and they focus on critical thinking, creativity, sense of initiative, problem-solving, risk assessment, decision taking and construction management of emotions.

Resource: Structure of the National Education System (https://eacea.ec.europa.eu/national-policies/eurydice/)

ITALY

The Italian school system takes as a reference the key competences for lifelong learning defined by the European Parliament and the Council of the European Union (Recommendation of 18 December 2006) The reference framework outlines eight key competences and describes knowledge, skills and attitudes which are essential to them. They are:

- Literacy
- Multilingualism
- Numerical, scientific and engineering skills
- Digital and technology-based competences
- Interpersonal skills, and the ability to adopt new competences
- Active citizenship
- Entrepreneurship
- Cultural awareness and expression

ROMANIA

The *official curriculum* is organised around 8 key competences areas:

- ❑ Literacy (mother tongue)
- ❑ Multilingual competences (foreign languages)
- ❑ Mathematical competences (problem solving)
- ❑ Digital competences (use of ICT)
- ❑ Personal competences (learning to learn)
- ❑ Social competences (citizenship)
- ❑ Entrepreneurship
- ❑ Cultural awareness and expression (interculturality)

We also try to develop transversal competences such as:

- Critical thinking
- Intercultural knowledge
- Self management
- Negotiation
- Leadership
- Flexibility anf adaptability

The transversal competences are developed in every subject in cross-curricular manner.

We also develop the key competences in non-formal and informal education:

- Extra-curriculum learning activities are embedded in the school programme
- Pupil exchange programmes with schools from abroad
- Projects in partnership with different agencies
- National or regional contests and competitions
- Volunteering

The infrastructure is very good in Romania, the download speed is 21.8 Mbps, and they were 14,387,477 Internet users in December 2018, which was73.8% of population.

Digital inclusion is a high priority in our educational system. The main goals are:

- Developing the ICT infrastructure and internet connection for the Romanian education institutions
- Training teachers
- Developing quality online resources
- Providing access to online learning spaces

There are some major programs (Holotescu, 2012):

- *EUR200 Program*
- *SEI Program*
- *Knowledge Economy Project (KEP)*
- *Wireless Campus*
- *IT system for educational management7*
- *Digital platform for OER — Virtual Library*

GERMANY

Technical knowledge

Students acquire competencies to deal with technical questions and content. They work on the content on the basis of interrelated basic concepts. The **basic concepts of** "matter", "system", "energy" and "reciprocity" describe and structure scientific content for the students. They form the basis of systematic knowledge building for the students from a technical and real-world perspective at the same time.

Knowledge acquisition

Students observe and describe phenomena, formulate questions and propose hypotheses. They plan their approach and learn relevant information using investigative and research methods. They apply technical and general scientific working practices in the process: tracing back to and classifying according to what they already know, systematising, comparing, proposing hypotheses, experimenting.

Communication

The ability to communicate based on fact and appropriate to the target audience using suitable media is an essential part of basic scientific education. This requires the right combination of everyday language and technical jargon.

Evaluation

By selecting appropriate content, students can recognise links between the individual scientific disciplines in everyday life, the environment and science. Students explore topics relevant to society from different per-spectives and learn that problem-solving depends on value judgements. They learn to differentiate between biological, chemical and physical facts, hypothetical and non-scientific statements in texts and images and are aware of the limits of the scientific perspective.

4- STUDENT PERFORMANCE IN SCIENCE (PISA 2018)

TURKEY

Science literacy is defined as the ability to engage with science-related issues, and with the ideas of science, as a reflective citizen. A scientifically literate person is willing to engage in reasoned discourse about science and technology, which requires the competencies to explain phenomena scientifically, evaluate and design scientific enquiry, and interpret data and evidence scientifically (OECD, https://gpseducation.oecd.org/CountryProfile?primaryCountry=TUR&treshold=10&topic=PI).

OECD Programme for Programme for International Student Assessment (PISA) measures the performance of 15-year-olds, who are enrolled in either lower secondary or upper secondary education. The measures the proficiency in literacy, mathematics and science of 15-year-old students. PISA results show that in many countries a large share of students have not even reached Level 2 on the six-level PISA scale. Such students lack the elementary skills required to read and understand simple texts, or to master basic mathematical and scientific concepts and procedures (OECD, 2020).

On average across OECD countries, 78% of students attained Level 2 or higher in science. At a minimum, these students can recognise the correct explanation for familiar scientific phenomena and can use such knowledge to identify, in simple cases, whether a conclusion is valid based on the data provided(OECD, https://gpseducation.oecd.org/CountryProfile?primaryCountry=TUR&treshold=10&topic=PI)

Turkey's mean performance in PISA 2018, in all three subjects, was not significantly different from that observed in 2009 or 2012. and was significantly higher than the level observed in 2003 and 2006. When considering results from all years, it is clear that PISA 2015 results – which were considerably lower – were anomalous, and neither the decline between 2012 and 2015, nor the recovery between 2015 and 2018, reflect the long-term trajectory. Overall, this trajectory is clearly positive in mathematics (over the 2003-2018 period) and in science (2006-2018). In Turkey, the average performance in science of 15-year-olds is 468 points, compared to an average of 489 points in OECD countries. Girls perform better than boys with a statistically significant difference of 7 points. Improvements of 10 points or more between 2015 and 2018 were observed in Turkey (43 score points) (PISA 2018 Report). The long term change in science mean performance over the period of participation of Turkey in PISA (2018) shows one of the strongest increases among PISA-participating countries and economies (OECD, https://gpseducation.oecd.org/CountryProfile?primaryCountry=TUR&treshold=10&topic=PI)

In PISA 2018, Turkey's science scores had increased by 6.1 points per cycle (EDUCATION POLICY OUTLOOK IN TURKEY). Although student performance has improved, a smaller share of students in Turkey achieve baseline proficiency (PISA level 2) in science than on average across the OECD. Mean performance in science in PISA 2018 was also below average, with smaller-than-average shares of students achieving baseline proficiency (PISA Level 2). (OECD, 2020)

Level 2 in science is an important benchmark for student performance: it represents the level of achievement, on the PISA scale, at which students begin to demonstrate the science competences that will enable them to engage in reasoned discourse about science and technology (OECD, 2018, p. 72[2]). At Level 2, the attitudes and competences required to engage effectively with science-related issues are only just emerging. Students demonstrate basic or everyday scientific knowledge, and a basic understanding of scientific enquiry, which they can apply mostly in familiar contexts. Students' skills progressively expand to less familiar contexts, and to more complex knowledge and understanding at higher levels of proficiency (OECD, 2019, PISA 2018 Report)

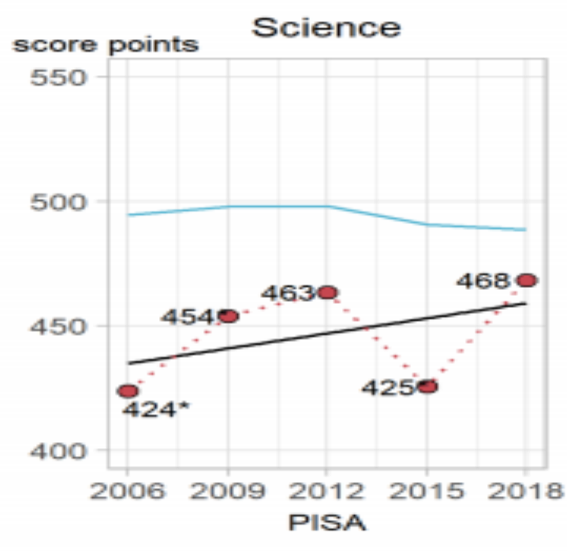
What students know and can do in science?

• Some 75% of students in Turkey attained Level 2 or higher in science (OECD average: 78%). At a minimum, these students can recognise the correct explanation for familiar scientific phenomena and can use such knowledge to identify, in simple cases, whether a conclusion is valid based on the data provided.

• In Turkey, 2% of students were top performers in science, meaning that they were proficient at Level 5 or 6 (OECD average: 7%). These students can creatively and autonomously apply their knowledge of and about science to a wide variety of situations, including unfamiliar ones (OECD, 2019, PISA 2018 Turkey Report).

Chart 4. Trends in performance in science

Turkey OECD Average Trend - Turkey



Turkey's performance has improved; since 2006, mean scores in science. Turkey achieved this while expanding participation: between 2003 and 2018, the share of students eligible for the PISA test as a proportion of all 15-year-olds more than doubled) (OECD, 2020). Turkey has one of the largest 15-year-old populations among PISA-participating countries and economies (OECD, https://gpseducation.oecd.org/CountryProfile?primaryCountry=TUR&treshold=10&topic=PI)

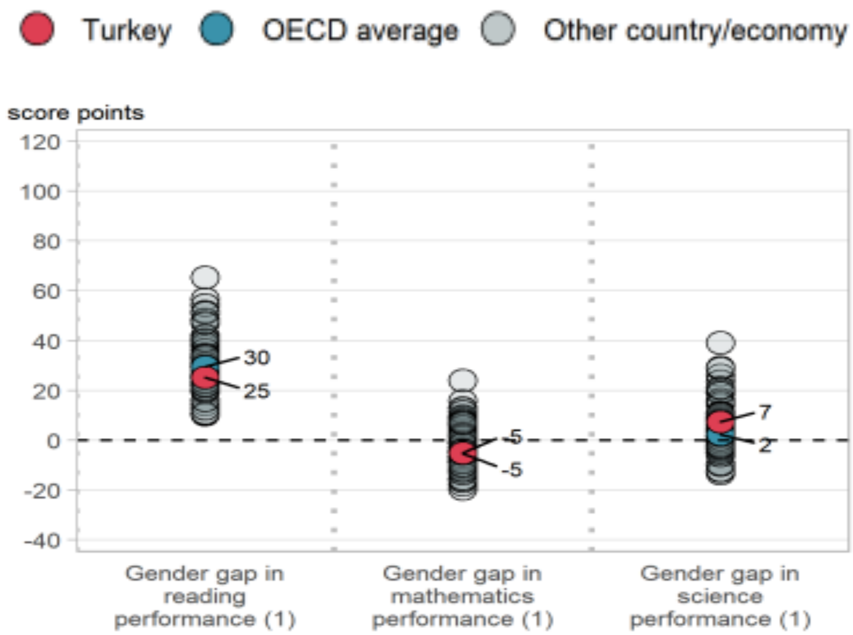
Chart 5. Snapshot of performance trends in Turkey

Snapshot of performance trends in TURKEY

Mean performance	Reading	Mathematics	Science
PISA 2000	m		
PISA 2003	441*	423*	
PISA 2006	447*	424*	424*
PISA 2009	464	445	454*
PISA 2012	475	448	463
PISA 2015	428*	420*	425*
PISA 2018	466	454	468
Average 3-year trend in mean performance	+2.2	+4.1*	+6.1*
Short-term change in mean performance (2015 to 2018)	+37.3*	+33.1*	+42.8*
Overall performance trajectory	hump-shaped (more negative over more recent years)	steadily positive	steadily positive
Proficiency levels	**Reading (2009 to 2018)**	**Mathematics (2012 to 2018)**	**Science (2006 to 2018)**
Percentage-point change in top-performing students (Level 5 or 6)	+1.5*	-1.1	+1.5*
Percentage-point change in low-achieving students (below Level 2)	+1.6	-5.3	-21.4*
Variation in performance	**Reading (2003 to 2018)**	**Mathematics (2003 to 2018)**	**Science (2006 to 2018)**
Average trend amongst the highest-achieving students (90th percentile)	+0.7	-0.2	+5.1*
Average trend amongst the lowest-achieving students (10th percentile)	+3.4*	+6.3*	+4.8*
Gap in learning outcomes between the highest- and lowest-achieving students	stable gap	narrowing gap	stable gap

* indicates statistically significant trends and changes, or mean-performance estimates that are significantly above or below PISA 2018 estimates.
Source: OECD, PISA 2018 Database, Tables I.B1.7–I.B1.15 and I.B1.28–I.B1.30.

Chart 6. Differences in performance related to personal characteristics



Notes: Only countries and economies with available data are shown. (1) Girls' minus boys' performance;

Source: OECD, PISA 2018 Database, Tables II.B1.2.3, II.B1.7.1, II.B1.7.3, II.B1.7.5 and II.B1.9.3.

Equity related to socio-economic status

Socio-economic status was a strong predictor of performance in mathematics and science in all PISA participating countries. It explained 11% of the variation in mathematics performance in PISA 2018 in Turkey (compared to 14% on average across OECD countries), and 11% of the variation in science performance (compared to the OECD average of 13% of the variation) (OECD, 2019, PISA 2018 Turkey Note).

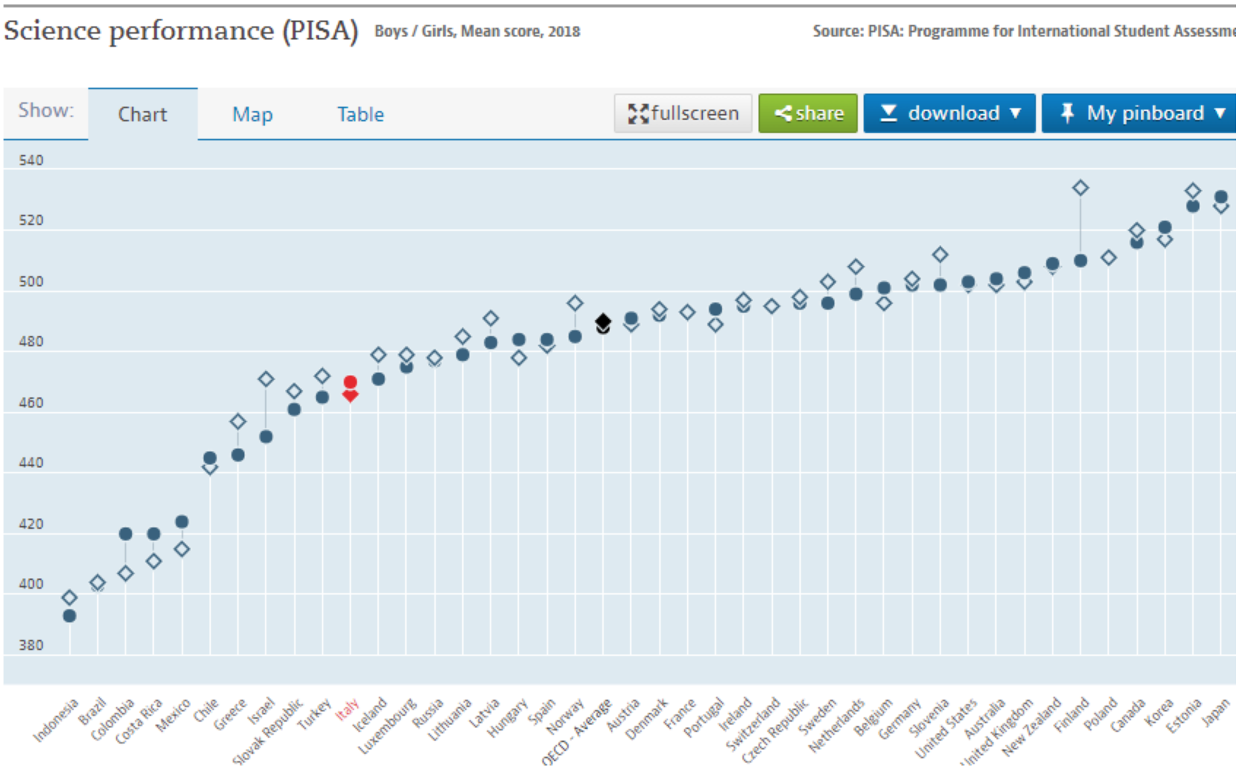
Equity related to gender

Amongst high-performing students in mathematics or science, one in three boys in Turkey expect to work as an engineer or science professional at the age of 30, while about one in five girls expects to do so (the difference is not statistically significant). About one in two high-performing girls expects to work in health-related professions, while about one in four high-performing boys expects to do so. Some 2% of boys and a negligible percentage of girls in Turkey expect to work in ICT-related professions (OECD, 2019, PISA 2018 Turkey Note).

ITALY

Scientific performance, for PISA, measures the scientific literacy of a 15 year-old in the use of scientific knowledge to identify questions, acquire new knowledge, explain scientific phenomena, and draw evidence-based conclusions about science-related issues. The mean score is the measure.

Chart 7. ITALY: Data comparison between 2006 and 2018 (LATEST UPDATE)



2012 - Science Italy is one the countries with the largest improvement in science performance between 2006 and 2012. Mean science performance among 15-year-olds in Italy however remains below the OECD average. • Students in Italy score 494 points in science, on average – below the OECD average, and comparable to the performance of students in Croatia, Denmark, France, Hungary, Lithuania, Luxembourg, Norway, Portugal, Spain and the United States.

• Italy's mean performance improved by 18 score points between 2006 and 2012, with most of the improvement occurring between 2006 and 2009. ITALY – Country Note –Results from PISA 2012 © OECD 3 • The share of low-performing students in science (18.7%) is larger than the OECD average but it shrank by 6.6 percentage points between 2006 and 2012. At best, these students can present scientific explanations that are obvious and follow explicitly from given evidence.

• The share of top-performing students in science (6.1%) is below the OECD average and increased by 1.5 percentage points between 2006 and 2012. Top-performing students can identify, explain and apply scientific knowledge and knowledge about science in a variety of complex life situations.

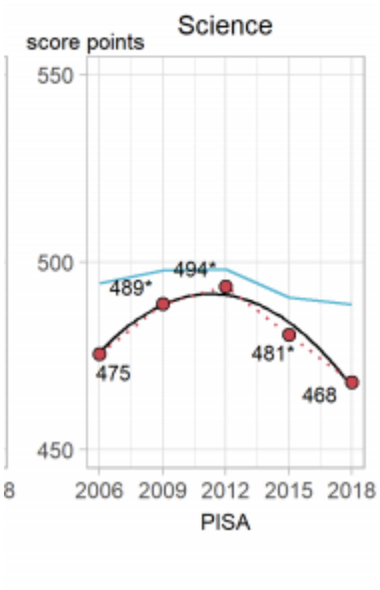
• Girls and boys perform at similar levels in science.

2018 - Some 74% of students in Italy attained Level 2 or higher in science (OECD average: 78%). At a minimum, these students can recognise the correct explanation for familiar scientific phenomena and can use such knowledge to identify, in simple cases, whether a conclusion is valid based on the data provided.

• In Italy, 3% of students were top performers in science, meaning that they were proficient at Level 5 or 6 (OECD average: 7%). These students can creatively and autonomously apply their knowledge of and about science to a wide variety of situations, including unfamiliar ones.

TRENDS IN PERFORMANCE IN SCIENCE

Chart 8. Science PISA



Over the 2006-18 period, science performance declined most markedly amongst the highest-achieving students. The 90th percentile of performance in science, i.e. the level above which only 10% of all students scored, declined by 4.3 score points per 3-year period, significantly faster than the 10th percentile. As a result, performance gaps in science narrowed, and the proportion of students who scored at Level 5 or 6 in science (top-performing students) shrank by 1.9 percentage points.

Key findings

• In 2018, Italy scored below the OECD average in reading and science, and around the OECD average in mathematics. Mean performance in Italy declined, after 2012, in reading and science, and remained stable (and above the level observed in 2003 and 2006) in mathematics. Reading performance declined, in particular, amongst girls (and remained stable among boys). Science performance declined most markedly amongst the highest-achieving students, by a similar amount for both boys and girls.

ITALY: A GENERAL OVERVIEW (OECD Skills Strategy Diagnostic Report)

Italy needs to take prompt action to bolster growth and improve people's skills across the country. As our economies adapt to globalisation, technological and demographic change, the demand for new and higher levels of skills increases. Yet Italy is struggling more than other advanced economies to meet these changing demands. Italy has launched a number of ambitious reforms to boost growth. But the reforms need to be fully implemented to ensure that schools, universities and workplaces equip all Italians with the skills needed for success in the economy and society. The OECD Skills Strategy Report makes a number of recommendations that will help sustain this positive momentum including, among others, to:

1) implement the Alternanza Scuola Lavoro (ASL) by training school principals and teachers to effectively engage employers in the design of work-based learning activities and increase incentives for firms to hire trainees;

2) expand and improve the quality of professional tertiary education institutions (ITS);

3) increase overall investment in tertiary education;

4) subsidise training programmes that target low-skilled adults who often face difficulties in accessing such opportunities;

5) increase public and private investment in skills and improve how they are allocated through monitoring and evaluation;

6) improve the governance system to ensure that skills policies are aligned and coordinated.

In Italy, the average performance in science of 15-year-olds is 468 points, compared to an average of 489 points in OECD countries. Boys perform better than girls with a non statistically significant difference of 3 points (OECD average: 2 points higher for girls).

Percentage of students at each proficiency level in science

	All students															
	Below Level 1b (below 260.54 score points)		Level 1b (from 260.54 to less than 334.94 score points)		Level 1a (from 334.94 to less than 409.54 score points)		Level 2 (from 409.54 to less than 484.14 score points)		Level 3 (from 484.14 to less than 558.73 score points)		Level 4 (from 558.73 to less than 633.33 score points)		Level 5 (from 633.33 to less than 707.93 score points)		Level 6 (above 707.93 score points)	
	%	S.E.	%	S.E.	%	S.E.	%	S.E.	%	S.E.	%	S.E.	%	S.E.	%	S.E.
OECD																
Australia	0,6	(0,1)	4,5	(0,3)	13,7	(0,5)	23,0	(0,6)	27,5	(0,6)	21,2	(0,6)	7,9	(0,4)	1,6	(0,2)
Austria	0,6	(0,2)	4,8	(0,5)	16,5	(0,9)	25,0	(0,8)	27,6	(0,8)	19,2	(0,8)	5,8	(0,6)	0,5	(0,1)
Belgium	0,6	(0,1)	5,3	(0,5)	14,2	(0,6)	22,2	(0,7)	28,4	(0,8)	21,3	(0,7)	7,3	(0,4)	0,7	(0,2)
Canada	0,4	(0,1)	2,6	(0,2)	10,5	(0,4)	22,4	(0,6)	29,3	(0,6)	23,5	(0,7)	9,5	(0,5)	1,8	(0,2)
Chile	1,0	(0,2)	8,8	(0,7)	25,5	(1,0)	33,1	(1,0)	22,6	(1,0)	7,9	(0,6)	1,0	(0,2)	0,0	(0,0)
Colombia	2,1	(0,3)	15,3	(1,1)	33,0	(1,1)	29,6	(1,2)	15,4	(0,8)	4,2	(0,4)	0,4	(0,1)	0,0	(0,0)
Czech Republic	0,4	(0,1)	3,9	(0,4)	14,5	(0,8)	25,9	(1,0)	28,7	(1,0)	19,1	(0,8)	6,6	(0,5)	1,0	(0,2)
Denmark	0,7	(0,2)	4,1	(0,3)	13,9	(0,6)	26,6	(0,7)	30,1	(0,9)	19,1	(0,8)	5,0	(0,5)	0,5	(0,2)
Estonia	0,1	(0,1)	1,1	(0,2)	7,5	(0,5)	21,5	(0,7)	32,1	(0,9)	25,4	(0,8)	10,2	(0,5)	2,0	(0,2)
Finland	0,4	(0,1)	2,8	(0,3)	9,7	(0,6)	21,1	(0,7)	28,9	(0,8)	24,9	(0,8)	10,5	(0,6)	1,8	(0,3)
France	0,6	(0,2)	5,0	(0,4)	14,9	(0,8)	24,6	(0,9)	28,3	(0,7)	20,0	(0,9)	5,9	(0,5)	0,6	(0,1)
Germany	0,8	(0,2)	5,0	(0,5)	13,8	(0,7)	22,0	(0,9)	26,9	(0,9)	21,5	(1,0)	8,5	(0,6)	1,5	(0,2)
Greece	1,2	(0,3)	8,1	(0,8)	22,4	(1,0)	31,6	(0,9)	26,0	(1,0)	9,3	(0,6)	1,3	(0,2)	0,0	(0,0)
Hungary	0,6	(0,2)	5,7	(0,6)	17,8	(0,9)	26,1	(1,0)	28,1	(0,9)	17,0	(0,7)	4,3	(0,5)	0,4	(0,1)
Iceland	0,5	(0,2)	5,9	(0,5)	18,6	(0,8)	28,3	(0,9)	27,7	(1,0)	15,2	(0,8)	3,6	(0,4)	0,2	(0,1)
Ireland	0,3	(0,1)	3,3	(0,3)	13,4	(0,7)	26,9	(0,9)	31,3	(0,9)	19,0	(0,7)	5,4	(0,5)	0,5	(0,2)
Israel	3,2	(0,4)	10,7	(0,7)	19,2	(0,9)	23,1	(0,9)	22,9	(0,8)	15,1	(0,8)	5,2	(0,4)	0,7	(0,1)
Italy	1,1	(0,2)	6,6	(0,5)	18,2	(0,9)	30,2	(1,0)	27,8	(1,1)	13,4	(0,7)	2,6	(0,4)	0,2	(0,1)
Japan	0,2	(0,1)	1,8	(0,3)	8,9	(0,6)	19,9	(0,8)	29,7	(1,1)	26,5	(0,9)	11,4	(0,7)	1,6	(0,3)
Korea	0,5	(0,1)	3,1	(0,3)	10,6	(0,7)	21,0	(0,8)	28,6	(0,9)	24,5	(0,9)	10,0	(0,6)	1,8	(0,3)

Chart 9. Data reported in the spreadsheet above (last updated 24th July 2020) are to be read on the basis of the Science performance band definitions on the PISA scale, as follows:

Table 15.2 **Science performance band definitions on the PISA scale**

Level	Score points on the PISA scale
6	Higher than 707.93
5	Higher than 633.33 and less than or equal to 707.93
4	Higher than 558.73 and less than or equal to 633.33
3	Higher than 484.14 and less than or equal to 558.73
2	Higher than 409.54 and less than or equal to 484.14
1a	Higher than 334.94 and less than or equal to 409.54
1b	Higher than 260.54[3] and less than or equal to 334.94
1c	185.94 to less than or equal to 260.54

Italian students performance in science

The highest percentage of Italian students (30.2%) settles on level 2 which corresponds to the following level on the Science proficiency scale:

"At Level 2, students are able to draw on scientific content knowledge or procedural knowledge to identify an appropriate scientific explanation, interpret data, and identify the question being addressed

in a simple experimental design. They can use basic or everyday scientific knowledge to identify a valid conclusion from a simple data set. Level 2 students demonstrate basic epistemic knowledge by being able to identify questions that could be investigated scientifically."

A remarkable number of students (27.8) settles on level 3 which corresponds to the following level:

"At Level 3, students can draw upon moderately complex content knowledge to identify or construct explanations of familiar phenomena. In less familiar or more complex situations, they can construct explanations with relevant cueing or support. They can draw on elements of procedural or epistemic knowledge to carry out a simple experiment in a constrained context. Level 3 students are able to distinguish between scientific and nonscientific issues and identify the evidence supporting a scientific claim."

ROMANIA

One of the challenges is PISA (Programme for International Student Assessment) exams. Romania has been participating to this program since 2001. The last survey was in 2018:

- students in Romania scored lower than the OECD average in reading, mathematics and science

- in mathematics and science, students at different levels in the performance distribution followed distinct trends, and gaps in performance widened(© OECD 2019 Volumes I-III)

In Romania, low-performing students are clustered in certain schools to the same extent as the OECD average,and high-performing students more often clustered. A disadvantaged student has a 13% chance, on average, of being enrolled in a school with those who score in the top quarter of reading performance (OECD average: a 17% chance).

In 2018 half of the students in our country attained Level 2 or higher in mathematics (OECD average: 76%). These students can interpret and recognize, without direct instructions, how a simple situation can be represented mathematically.

In Romania, 3% of students scored at Level 5 or higher in mathematics (OECD average: 11%). These students can model complex situations mathematically, and can select, compare and evaluate appropriate problem-solving strategies for dealing with them. 80% of the Romanian students (OECD average: 67%) reported that they are satisfied with their lives (students who reported between 7 and 10 on the 10-point life-satisfaction scale).

93% of students in Romania reported sometimes or always feeling happy and about 4% of students reported always feeling sad. In most countries and economies, students were more likely to report positive feelings when they reported a stronger sense of belonging at school and greater student co-operation, and were more likely to express sadness when they were bullied more frequently.

In Romania, 91% of students agreed or strongly agreed that they can usually find a way out of difficult situations (OECD average: 84%), and 46% agreed or strongly agreed that, when they fail, they worry about what others think of them (OECD average: 56% of students). In almost every education system, including Romania, girls expressed greater fear of failure than boys, and this gender gap was considerably wider amongst top-performing students.

A majority of students across OECD countries holds a growth mindset (they disagreed or strongly disagreed with the statement "Your intelligence is something about you that you can't change very much"). In Romania, 43% of students hold a growth mindset.

There are some national educational projects which aim to improve our students results in Pisa and national exams:

- CRED (Relevant Curriculum, Open Education for All):

- training in curriculum improvement for 55.000 teachers

- ROSE (Romanian Secondary Education Project):

- investments in 271 high schools (decreasing school drop-out and increasing the results of the baccalaureat exam)

- The "Educated Romania" Presidential Program 2016

OurteachersuseOpen EducationResources, such as:

- digital content for every school subject
- educational projects
- handbooks
- applications and softs
- teaching – learning scenarios, etc.

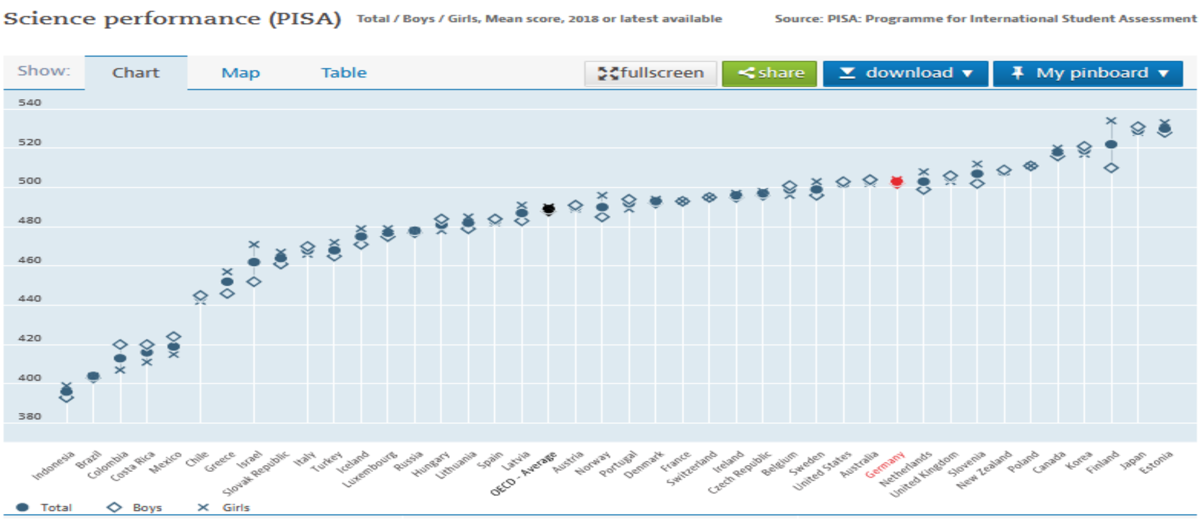
In Romania, girls scored similar to boys in mathematics in PISA. Across OECD countries, boys outperformed girls by five score points. While girls slightly outperformed boys in science (by two score points) on average across OECD countries in PISA 2018, in Romania girls and boys performed similarly in science.

Amongst high-performing students in mathematics or science, one in eight boys in Romania expect to work as an engineer or science professional at the age of 30, while one in nine girls expects to do so (the difference is not statistically significant). About one in three high-performing girls expects to work in health-related professions, while fewer than one in ten high-performing boys expect to do so. Some 14% of boys and 2% of girls in Romania expect to work in ICT-related professions.

GERMANY

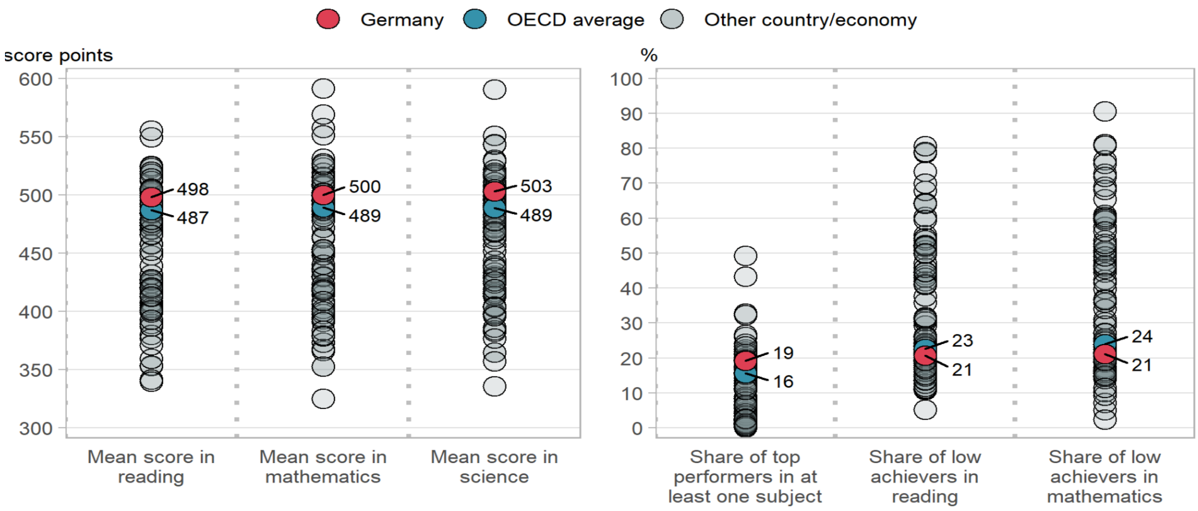
Scientific performance, for PISA, measures the scientific literacy of a 15 year-old in the use of scientific knowledge to identify questions, acquire new knowledge, explain scientific phenomena, and draw evidence-based conclusions about science-related issues. The mean score is the measure.

Chart 10. *Science performance (PISA)*[3]



Students in Germany scored above the OECD average in reading (498 score points), mathematics (500) and science (503). Germany's average performance in at least two of the three subjects was not statistically significantly different from that of Australia, Belgium, the Czech Republic, France, Ireland, New Zealand, Norway, Slovenia, Sweden, the United Kingdom and the United States. Germany's performance was lower in all three subjects in comparison with Beijing, Shanghai, Jiangsu and Zhejiang (China) (combined), Canada, Estonia, Finland, Hong Kong (China), Ireland, Korea, Macao (China), New Zealand, Poland and Singapore. Average reading performance in 2018 returned close to levels that were last observed in 2009, reversing most of the gains observed over the early period (up to 2012). In science, mean performance was below 2006 levels; while in mathematics PISA 2018 results lay significantly below those of PISA 2012.

Chart 11. Snapshot of performance in reading, mathematics and science [4]



• Students in Germany scored higher than the OECD average in reading, mathematics and science.

[3] Science performance for PISA: https://data.oecd.org/pisa/science-performance-pisa.htm
[4] OECD, PISA 2018 Database, Tables I.1 and I.10.1.

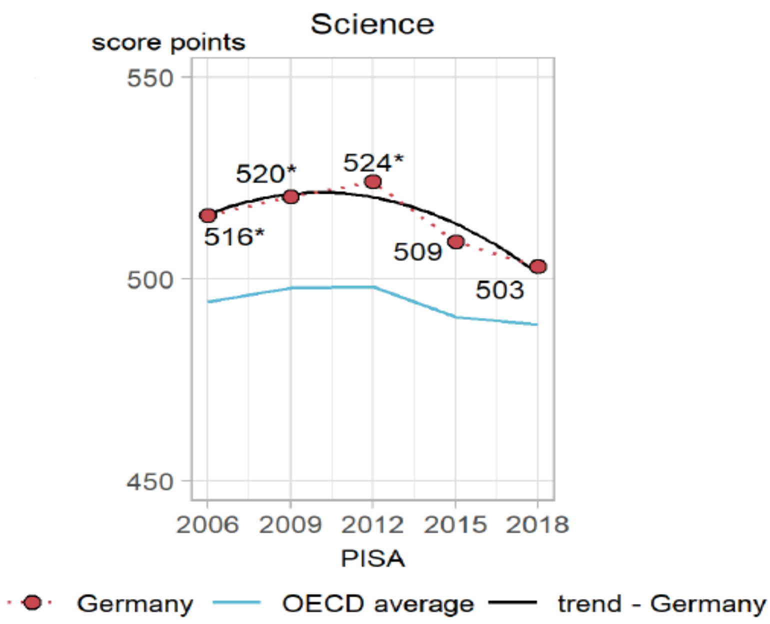
• Compared to the OECD average, a larger proportion of students in Germany performed at the highest levels of proficiency (Level 5 or 6) in at least one subject; while a similar proportion of students achieved a minimum level of proficiency (Level 2 or higher) in all three subjects.

What students know and can do in science

• Some 80% of students in Germany attained Level 2 or higher in science, compared with 78% on average across OECD countries. These students can recognise the correct explanation for familiar scientific phenomena and can use such knowledge to identify, in simple cases, whether a conclusion is valid based on the data provided.

• Some 10% of students in Germany (7% on average across OECD countries) were top performers in science, meaning that they were proficient at Level 5 or 6. These students can creatively and autonomously apply their knowledge of and about science to a wide variety of situations, including unfamiliar ones. (**OECD, PISA 2018 Germany Report**)

Chart 12. Science PISA



• In Germany, mean science performance was below 2006 levels; while in mathematics PISA 2018 results lay significantly below those of PISA 2012.

• However, demographic changes accounted only for a small part of the larger negative trends observed in mathematics and science since 2012.

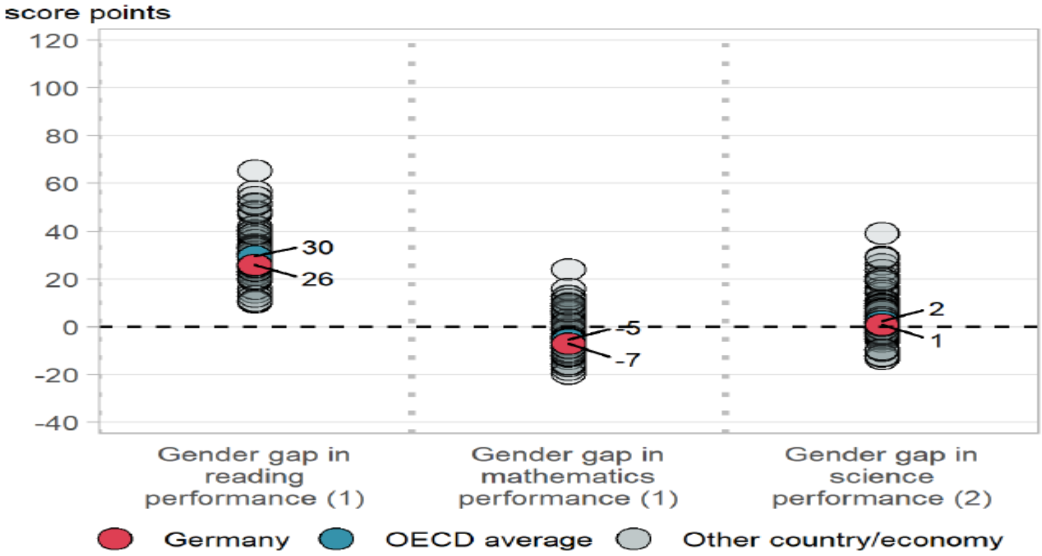
• Over the most recent period, performance trends in Germany differed by gender. Between 2015 and 2018, girls' performance in mathematics and science remained stable, while mean scores amongst boys declined by 11 points in mathematics and by 12 points in science. In mathematics, while there was no overall trend in mean performance over the full 2003-18 period, the trend was negative amongst the highest-achieving students (those at the 90th percentile).[5]

Where All Students Can Succeed ?

Only countries and economies with available data are shown. (1) Girls' minus boys' performance;

[5] Source: OECD, PISA 2018 Database, Tables I. B1.10, I. B1.11 and I. B1.12.

Chart 13. *Differences in performance and expectations related to personal characteristics*[6]



5- DIFFICULTIES ENCOUNTERED IN SCIENCE TEACHING

TURKEY

The way teaching is organised and delivered, together with other factors such as class sizes or the human and financial resources available in schools, can have a strong impact on student learning outcomes (OECDilibrary, https://www.oecd-ilibrary.org/papers/turkey).

In Turkey (Bakaç, 2020; Cumaoğlu, Şimşek, 2019; Emin, 2019; OECD, 2019):

- The average class-size of 15 year-olds is comparatively large
- The average level of student's life satisfaction is one of the lowest among countries and economies participating in PISA. Students in Turkey report to have one of the weakest positive feelings, compared to other PISA-participating countries and economies. A large proportion of students reported always feeling sad in Turkey, compared to other PISA-participating countries and economies
- The shortage of schools' educational material is one of the lowest among PISA-participating countries and economies.
- A small share of students attend schools whose principal reported that the school's capacity to provide instruction is hindered to some extent or a lot by a lack of physical infrastructure.
- PISA results also provide the opportunity to evaluate the performance of regions and school types. Considering the difference between regions according to the results of 2018, it is seen that there is a decrease in performance as we move from the west to the east of the Turkey. Therefore, starting from the principles of equality and justice in education, it seems essential to develop policies towards disadvantaged regions.

[6] Source: OECD, PISA 2018 Database, Tables II.B1.2.3, II.B1.7.1, II.B1.7.3, II.B1.7.5 and II.B1.9.3.

- When the performances of school types are examined, it is noteworthy that there is a hierarchical difference between school types in PISA 2018. While the highest performance among high school types is exhibited in the science high school in all three fields, the performance ranking is realized as social sciences high school, Anatolian high school, Anatolian imam hatip high school, vocational and technical Anatolian high school and multi-program high schools. Therefore, this difference between school types should be reduced.
- Comparing with other countries, investment in education is low.
- Teachers are of the opinion that the science education applied in Turkey remains theoretical. They state that they have difficulties between achievement and implementation, and there is not much time left for the implementation to develop the program.
- Teachers emphasize that there are no suitable laboratories to practice.
- Teachers in public school say that they can devote little time to practice to train the outcomes.
- Teachers complain that the science curriculum is knowledge-based. They are of the opinion that while they want to teach a subject in depth and by doing, they are taught lessons devoid of practice in order to train the subjects.
- Teachers emphasize that there are few teachers who can adapt to changing programs, improve and change themselves.
- Teachers stated that there are mostly questions related to higher level levels for students in PISA exams, they emphasized that they could not give students these features enough, the questions they asked in the exams did not measure these levels and that there were problems stemming from themselves.

6- TEHNOLOGY IN EDUCATION

TURKEY

In 2010, Turkey launched the Movement to Enhance Opportunities and Improve Technology (FATİH) project, aiming to extend and enhance the use of technology in teaching and learning. The project was initially a collaborative effort led by the Ministry of National Education with the support of several other ministries, the Treasury and the Scientific and Technological Research Council. FATİH has evolved into a longer-term programme that seeks to foster digital skills and improve access to Information and Communication Technologies (ICT) in schools. The project has five key lines of action (OECD, 2020):

• Establishing the necessary infrastructure, including broadband internet connection, tablets, interactive boards, and online platforms;

• Developing and managing online educational content and resources;

• Promoting the effective application of ICT in teaching programmes;

• Offering professional development to teachers including face-to-face and online training;

• Ensuring the ethical, reliable, manageable, and measurable use of ICT.

Initially, headline goals of the project included every student in secondary education receiving a tablet device and every classroom having an interactive whiteboard (IWB). This would be delivered in three phases focusing first on general secondary schools, then vocational schools, then primary and pre-primary schools. According to one early evaluation of FATİH (2013), after just the first year of national roll-out, 84 000 classrooms had been equipped and 63 000 tablets distributed. The aim to provide professional development to 680 000 teachers was also underway: a 30-hour ICT in education programme and a 25-hour preparatory course were launched in 2012 with over 120 000 participants within the first year. Distance learning centres were also set up in all provinces to facilitate professional development in the future. Administrative support was strengthened: by 2018, there were 500 FATİH trainers in schools helping to solve school-level issues, with a further 700 rotating between schools. However, following medium-scale piloting, the project was adapted, since the pedagogical model and educational outcomes of the original plan were not satisfactory (OECD, 2020).

From 2018, with the introduction of the Education Vision 2023, the development of the Education Information Network (EBA) gained importance. EBA is the official national digital education platform, providing interactive and subject-specific digital content for students and teachers across Turkey from pre-school to upper secondary education. EBA aims to provide collaborative digital learning opportunities through the creation of alternative communication channels between teachers and learners and the development of personalised learning plans for individual learners. Features include a smart content recommendation system, gamified features such as points and badge collection, and the EBA Portfolio where students can display their achievements and their work. For older students, an EBA Academic Support feature has been developed to provide adaptive individualised learning based on artificial intelligence assisted analytics. Furthermore, to support teachers, sub-portals focused on professional development and digital library resources are available, and the EBA Professional Development Platform provides online support for teachers' continuous professional development (OECD, 2020).

By 2019, targeted coverage of the digital infrastructure reached 47 158 schools within the FATİH project, revising the original target of 40 000 schools. Nearly 450 000 IWBs were installed, more than 1.4 million tablet computers were distributed to upper secondary level students and teachers, and approximately 1 million teachers had enrolled in either online or onsite professional development. Perhaps more significantly, the EBA became the cornerstone of Turkey's educational response to the COVID-19 pandemic and consequent school closures; further efforts were made during this period to enhance various features and tools (OECD, 2020).

The MoNE's annual report (2018) shows positive results on both the number of EBA visits - which was up to 1 billion - and the annual increase in number of online support materials – just under 2 000. Further research regarding teachers' concerns (2018) suggests positive views among practitioners regarding the commitment to improving digital infrastructure and addressing inequalities, as well as the availability of digital teaching information and resources. However, teachers also report some concerns related to using the digital resources, including the quality of educational content and classroom time management issues. There have also been concerns about the quality and coverage of professional development: teachers may be benefitting from support to digitise their teaching but not necessarily to enhance it. Finally, in terms of governance, approaches to the digital transformation of teaching and learning appear to require a clearer, more coherent vision. Turkey intends to continue enriching digital content through the EBA in order to become a model of effective and equitable distance learning, and to build on the foundations of FATİH to continue strengthening network infrastructure in schools across the country (OECD, 2020).

ROMANIA

ICT and Informatics education

The evolution of the Romanian society is deeply influenced by the orientation towards the digital content. There are strategies and programs for students and long-life education for adults, e.g. ECDL (European Computer Driving License), IC3 (Internet and Computing Core Certification)
Romania integrated the learning of ICT and Informatics into the national policies of modern curricula of education and professional training. Starting with 2010 the Baccalaureate exam includes the certificate of digital competence. Informatics is one of the school subjects to be chosen for Baccalaurate exam.

ICT and Informatics education in the secondary and higher education systems

The curriculum of each educational track (theoretical, technological, and vocational) includes, for every profile and specialization, one of the disciplines *ICT* or *Informatics* in every year of study. Teaching follows key competencies: digital competences, competences in mathematics and basic competences in sciences and technology.
Informatics is taught in the theoretical track, for the Mathematics-Informatics profile - 1 hour/week in the 9th and 10th grades and 4 hours/week in the 11th and 12th grades. Special classes (called "intensive") teach 4 and 7 hours/week respectively.

GERMANY

To ensure that students develop the abilities they need for evaluation and decision-making, knowledge and experience are necessary to broaden their perspective, allowing them to see and experience not just the colourful and appealing multimedia-based interfaces of applications, but also the underlying structures. This is the only way a knowledge-based assessment is possible of the role and mutually reinforcing relationship between humans and electronic devices in present and future society. ICT education at secondary level I comprises two areas:

Basic ICT course at levels D and E:

This area (ICT) has two areas of focus: acquiring the practical skills needed to use the computer as a tool and pre-paring students to participate in a society that is shaped to a large extent by information and communications technology. The levels are covered by the topics standard software, ICT systems and living in and with networked systems (see below).

Voluntary elective at levels F, G and H:

Here, students acquire knowledge and experience related to the structure and function of ICT systems and gain ini-tial insights into techniques of formal modelling (visualising and structuring data and data processing steps, using data objects to represent real objects).

What competencies do students acquire in ICT and computer science class?

Reciprocal relationships between computer systems, humans and society: Students explain e.g. how IT sys-tems permeate and change everyday life and careers. They assess and evaluate the opportunities and risks of current developments for the individual and society and draw conclusions for their own responsible con-duct.

Handling information: Students describe the difference between data and its interpretation. They make tar-geted use of digital data and help systems to get information. In the process, they develop an awareness of how to manage their own data and the importance of privacy in a democratic society.

Understanding IT systems: Students identify the components of different IT systems in their everyday envi-ronments and describe their functionality as the interaction between hardware and software components. They know how to use IT systems properly and observe and evaluate their own handling of these systems.

IT modelling: Students use IT models for problem analysis and solution design. They can implement models with suitable tools and reflect on the results. Students can describe the structure and functionality of com-puters and computer networks on the basis of models and have basic knowledge of the historical develop-ment of computer science.

Problem-solving: IT systems are characterised by systematic processes with algorithms at their core. Stu-dents design algorithms from different areas of application (e.g. robotics, encryption) and implement them using programming environments. They evaluate the multifaceted dependence of almost all areas of society on software products in the context of their knowledge of the possibilities for manipulation and the imper-fection of software algorithms.

Communication and cooperation: Students can make use of the different possibilities for communication, interaction and information in the area of networked computer systems for collaboration, they communi-cate in projects and adopt standpoints consistent with their role. They help each other apply the software in use to practical situations.

What topics and content are taught in the subject? Use of standard software, e.g.

- Using word processing software and at least one other software application (presentation, spread-sheet or graphic design)
- Using a browser
- Creating and giving their own presentations (in a project context)
- Selecting software to solve a specific problem, operating graphical user interfaces

Design and functionality of IT systems, e.g.

- Basic knowledge of computer operation using the example of the school's computer system
- Proficiency in the operation of hardware and software, structured storage of files
- Data protection and data traces (e.g. social networks, customer loyalty cards, discount systems, cost traps)
- Analysis and comparison of IT systems
- Social impact of IT systems (forms of communication, the working environment, free time activities, addiction problems, etc.)

Living in and with networked systems, e.g.

- Getting specific information from different sources when needed
- Using search engines properly
- Data exchange in the network
- Upholding netiquette conventions in digital communication, cyber-bullying
- Legal foundation (e.g. copyright in music sharing platforms)

Algorithmic problem-solving

- Modelling of simple workflows using algorithms
- Analysing, modifying and implementing algorithms
- Basic algorithmic structures (sequence, selection, loop)
- Using programming environments (also to control external devices, e.g. in robotics)
- Data modelling: data types, variables, describing objects based on their properties and methods

Databases

- Identifying and describing real-life data collections
- Planning and implementing the design of a simple database
- Data protection: right to informational self-determination, data privacy laws and rights, data traces, data mining, consumer protection, monitoring

Elective topics

- History of computer science
- Project management
- Physical computing
- Digital images and visualisation

7- TABLES

8- CHARTS

9- REFERENCES – RESOURCES

Bakaç, E. (2020). *PİSA 2018 Sonuçlarının Eğitim Yatırımları Bağlamında Değerlendirilmesi*. A.Doğanay, M. Oğuz Kutlu (Ed), Güncel Eğitim Bilimleri Araştırmaları (s.5-10) içinde. Ankara: Akademisyen Yayınevi

Cumaoğlu, Z. T., & Özdemir Şimşek, P. (2020). Uluslararası sınavlarda fen bilimleri derslerinden alınan sonuçların iyileştirilmesine yönelik fen bilimleri öğretmen görüşleri. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 35*(4), 949-970.

Emin, M.N. (2019). PISA 2018 Sonuçları Nasıl Okunmalıdır? Perspektif (setv.org), 251, 1-5

EURYDICE, https://eacea.ec.europa.eu/national-policies/eurydice/content/turkey_en

EURYDICE, https://eacea.ec.europa.eu/national-policies/eurydice/content/upper-secondary-and-post-secondary-non-tertiary-education-44_en

Holotescu, 2012

ISCED – International Standard Classification of Education

ITALY – Country Note –Results from PISA 2012 © OECD 3

Ministerial Decree 139 of 2007

OECD, Turkey Student Performance-PISA 2018. https://gpseducation.oecd.org/CountryProfile?primaryCountry=TUR&treshold=10&topic=PI

OECD (2018). *Turkey: Overview of the Education System*. OECD Education GPS. http://gpseducation.oecd.org/Content/MapOfEducationSystem/TUR/TUR_2011_EN.pdf

OECD (2019). *PISA 2018 Results (Volume I): What Students Know and Can Do*. PISA, OECD Publishing, Paris https://doi.org/10.1787/5f07c754-en.

OECD (2019), Education at a Glance 2019: OECD Indicators, OECD Publishing, Paris, https://doi.org/10.1787/f8d7880d-en

OECD (2020). *Education Policy Outlook in Turkey*. OECD Education Policy Perspectives, No: 23. https://www.oecd-ilibrary.org/education/education-policy-outlook-in-turkey_b7c69f4c-en

OECD (2020). *Education at a Glance 2020: OECD Indicators*. OECD Publishing, Paris, https://doi.org/10.1787/69096873-en

OECD Skills Strategy Diagnostic Report

OECD (2018) “Germany: Overview of the Education System” , OECD Education GPS

Recommendation of 18 December 2006

Scientific performance (PISA 2018)

Structure of the National Education System, https://eacea.ec.europa.eu/national-policies/eurydice/

PISA 2018

The Education System of Turkey, https://www.turkeyeducation.info/

TQF (2015). *Turkish Qualifications Framework*. Mesleki Yeterlik Kurumu, Ankara

TÜBİTAK. (2004). Ulusal Bilim ve Teknoloji Politikaları, 2003-2023 Strateji Belgesi, Versiyon 19. Ankara.

University, Afam and ITS Law 296 of 2006

© OECD 2019 Volumes I-III

https://mufredat.meb.gov.tr/Dosyalar/201812312311937-FEN%20B%C4%B0L%C4%B0MLER%C4%B0%20%C3%96%C4%9ERET%C4%B0M%20PROGRAMI2018.pdf