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Learn STEM

Innovative Model of learning STEM in secondary schools

School Education ERASMUS+
KA220-SCH -
Cooperation partnerships in school education

Overview on existing practices in teaching STEM through innovative pedagogical approaches for Türkiye

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Date:
30.08.2023

Reference Number:
2022-1-TR01-KA220-SCH-000087583

Content

1 The importance of STEM in Educational contexts

STEM (Science, Technology, Engineering, and Mathematics) education plays a critical role in educational contexts since it combines knowledge, skills (learning and practice), and dispositions required for active participation in the current society to face and overcome the challenges of the twenty-first century (McKinney, Tomovic, Grant & Hinton, 2017). STEM education promotes creativity, problem-solving, and critical thinking, as the 21st century learning skills. These abilities are essential for promoting an innovative and research-focused culture. The teaching of STEM is important in Türkiye for several reasons, as it is in many countries around the world. Numerous studies highlight Turkey's need for a well-developed STEM education. STEM Education studies should be collaboratively organized by Ministry of National Education and Turkish Universities.

First of all, STEM does not only involve the outcomes of Science, Technology, Engineering and Mathematics education, but also includes outcomes for the education of the other disciplines (English, 2016). Moreover, as well as being a pedagogical model to enrich the regular curriculum, the STEM approach should be integrated into the society due to its beneficial effects on economic, technologic, scientific development and also workforce (Chesky & Wolfmeyer, 2015). Türkiye can contribute to scientific development, create new technologies, and tackle difficult societal problems by investing in STEM education.

Technology innovation, economic growth, and job creation are all driven by STEM fields. Türkiye can create a trained workforce capable of making a contribution to a variety of industries, including technology, manufacturing, healthcare, and more by placing a strong emphasis on STEM education. As a result, the nation's economic competitiveness on the world stage may be improved.

In today's interconnected and technology-driven world, countries that excel in STEM education have a competitive advantage. By fostering a strong foundation in STEM subjects, Türkiye can participate in global research collaborations, attract foreign investment, and establish itself as a hub for technology and innovation.

In conclusion, STEM education funding in Turkey is crucial for innovation, societal challenges, economic growth, and global competitiveness. In addition to preparing people for fulfilling employment, it also gives them the knowledge and abilities they need to positively impact the growth of the country.

Sources:

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English, L. D. (2016). STEM education K-12: Perspectives on integration. International Journal of STEM Education, 3(1), 1–8.

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2 Presentation of examples for existing practices in teaching STEM in Türkiye

STEM applications have been increasing in Turkey in recent years. In this field, many institutions and organizations, ranging from so-called STEM schools to science and research centers and national networks, attach importance to STEM education. These centers are designed to help students develop their scientific and technological abilities, increase their interest in science and technology, and help them succeed in their future careers. Some examples of activities for teaching and practising STEM are given below.

2.1 Presentation of best practice 1: Havelsan Academy Engineer Child

HAVELSAN was established in 1982 as a company of the Turkish Armed Forces Foundation. Recognized as one of Turkey's largest technology companies, HAVELSAN is a leading brand in the international market with its experience, expert employees, software-intensive original solutions and products based on advanced technology. In addition to the high technology and software developed in-house. Thanks to its decades-long experience and highly qualified human resources, HAVELSAN provides high technology-based software-intensive solutions and products for armed forces, public and private sectors.

HAVELSAN as a reliable, sustainable, and strategic solution partner also leads the way for digital transformation both at home and abroad. HAVELSAN established the HAVELSAN Academy in this direction. HAVELSAN Academy was created for children and young people who always want to learn more about the vast knowledge in the field of science and technology. HAVELSAN Engineer Kids Social Responsibility Project meets thousands of children all around Turkey. Engineer Children are experiencing different experiences with STEM Workshops at HAVELSAN booths. Like the engineer child, Havelsan Academy evaluates the projects of Turkish young people with engineering dreams under Havelsan Engineer Teen and come together to provide technical mentoring support for their projects.

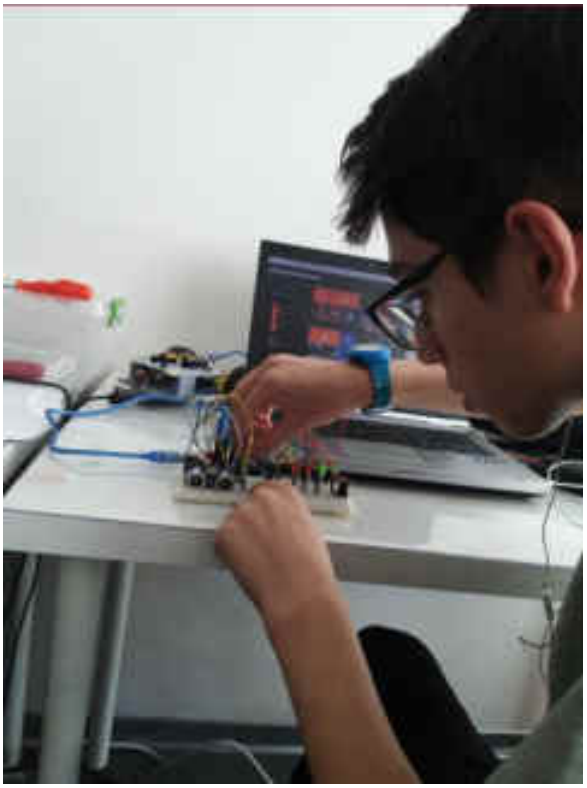
Source: Retrieved from https://akademi.havelsan.com.tr/muhendis-cocuk

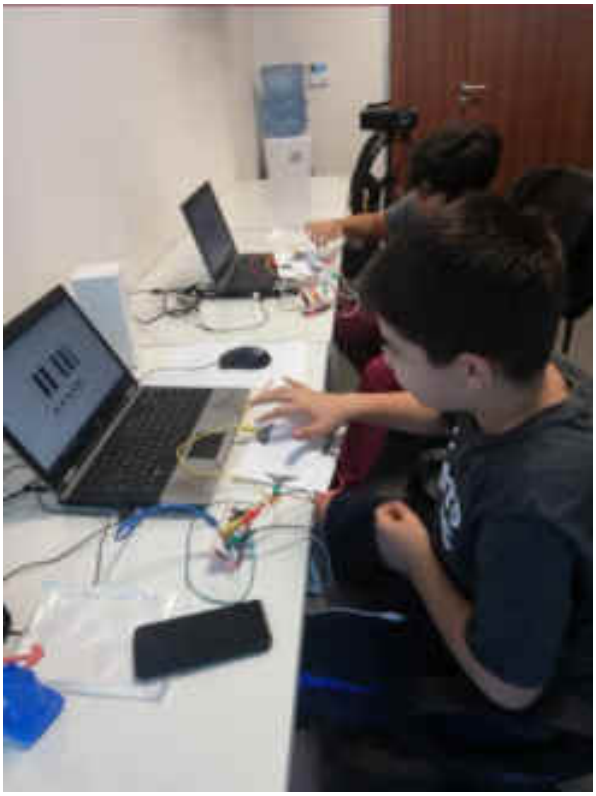
2.2 Presentation of best practice 2:Kivvi Academy

Kivvi Academy started its activities within Kivvi R&D in 2019. Within the framework of educational activities, robotic coding and STEAM trainings are provided, especially for the 8 - 16 age group. The materials and contents used in the trainings are prepared by expert educators and engineers within Kivvi Academy.

Training sets and contents prepared at different levels and for different purposes are created in line with the needs and feedback of teachers and students. Within this framework, practice-based and sustainable trainings are provided. Students are included in all possible stages of the product creation process. In this way, they can experience both the progress and the results of the processes with their own ideas. Training contents and training sets created by expert staff are also offered in a certified manner to trainers who request from outside the organization.

With Kivvi Academy, students and teachers receive 3D Design, Game Workshop, Robotics and Arduino and Coding trainings, creating the appropriate infrastructure for STEM.





Source: Retrieved from www.kivvi.com.tr

2.3 Presentation of best practice: Hacettepe STEM & Maker Lab's

Since 2009, Hacettepe Science, Technology, Engineering and Mathematics Education and Applications Laboratory (Hacettepe STEM & Maker Lab) which was, established within Hacettepe University, carries out various scientific activities. The research center has been participating in various projects within the scope of the European Union Framework Programs in order to disseminate up-to-date educational approaches in order to raise individuals to engineer the future of a society by empowering their imagination, creativity and innovation. Some of the projects of the research center are;

- Professional Development for European In- and Pre-Service STEM Teachers
- Perspectives for Lifelong STEM Teaching -Career Guidance, Collaborative Practice and Competence Development (3C4Life)
- Teaching Standard STEM Topics with a Key Competence Approach
- Integrated Approach to STEM Teacher Training (STEM)
- STEM Teacher Training Innovation for Gender Balance Toolkit
- INSTEM State of the Art Report

Every year, they organize a STEM & Makers Fest/Expo. STEM & Maker Fest/Expo is a member of European Public Engagement Association (EUSEA). STEM & Makers Fest/Expo aims to promote public engagement with Science, Technology, Engineering and Mathematics (STEM). It unites STEM practitioners, researchers, policy makers and public to enhance the quality of STEM education and broaden participation in STEM. So far, more than 200,000 participants from different age groups have engaged with STEM & Makers activities. The festivals have been held in 10 different provinces and the number of these provinces and people is increasing day by day with your contributions. STEM & Makers Fest/Expo has been organized in collaboration among universities, schools, local authorities and industry.

Source: Retrieved from https://hstem.hacettepe.edu.tr/

2.4 Presentation of best practice 4:Science Centers at different cities across Türkiye

Science centers aim to make science and technology comprehensible and accessible to society and to increase the importance of science and technology in the eyes of society by bringing individuals from different age groups and with different backgrounds together with science; include experimental and applied activities, encourage visitors to experiment and discover; pursue public interest, are not established to make a profit, and are financed by public or private sector resources. Many science centers in Turkey offer STEM activities. Here are some STEM centers and activities in Turkey

Konya Science Center: The STEM workshop offers students the opportunity to work with state-of-the-art tools such as 3D printers, laser cutters and other advanced tools. It tries to reach more children and more people from the community by organizing STEM days and Science festivals.

Bursa Science and Technology Center: Bursa Science and Technology Center provides students with education and experiences in science, technology, engineering and mathematics.

Gaziantep Science and Technology Center: Gaziantep Science and Technology Center educates students on STEM subjects and also organizes robotics and coding activities.

Izmir Science Center: Izmir Science Center allows visitors to conduct scientific experiments and receive education in STEM subjects.

These are just a few examples and there are many STEM centers across Turkey. Many of these centers offer free or low-cost activities to develop students' scientific and technological skills.

3 Final comment

Research in the field of STEM education is mostly conducted in a top-down manner. In other words, it is obvious that it consists only of proposals that are built on theoretical foundations but whose applications have not yet been tested in the field. It is certain that transforming the theoretical foundations into practices suitable for each stage will be more effective for STEM practitioners, teachers and students. From this perspective, first of all, teachers who will teach STEM should not lack theoretical and practical knowledge so that they can transfer it to their students. The examples given above can be given for the popularization of STEM.

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ERASMUS+ KA220
Cooperation partnerships in school education

Overview on existing practices in teaching STEM through innovative pedagogical approaches for Greece

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IEK KAVALAS

KAVALA/ GREECE

Date:
22.08.2023

Reference Number:
2022-1-TR01-KA220-SCH-000087583

Contents

1 The importance of STEM in Educational contexts

At SEV (Hellenic Federation of Enterprises) and Endeavor's Big Webinar, Innovative Community Kickoff Greeks, more than 10,000 people watched leading Greeks of innovation from all over the world to share knowledge and experiences on how to substantially strengthen the innovation ecosystem in Hellas. One of the common narratives that the speakers agreed upon is that of creation innovation, knowledge (scientific, technical, and horizontal) is important, alongside understanding that innovation and productivity go together. A second common finding was that the degree complexity, but also the scope, of the contemporary challenges of globalization, the digital transformation, and sustainability imposes access to many different specialties and to specialized skills. And the expected shift in the division of labor between people and machines is expected to eliminate approximately 85 million jobs by 2025, and create 97 million new mainly in the green economy, data analysis and artificial intelligence, but also in engineering, Cloud Computing, even business development or the development of new products (World Economic Forum 2020).

Greece can lay claim to an important position in the new international value chains, as long as we invest in extroversion, innovation, and sustainability. - The upgrading of our human capital involves covering major deficits education in Greece in order to be a main force for the production of innovation in our economy. - SEV systematically emphasizes the need to promote a modern education model and training, harmonized with the needs created by international competition, the transition to green and digital economy and the shifting division of labor between people and machines with the removal of 85 cm. jobs and the creation of 97m. of young people by 2025 (World Economic Forum 2020). - The most critical knowledge fields in this environment are STEM (Science, Technology, Engineering, Mathematics). They are at the core of the educational strategy in technology developing countries in Asia but Europe and North America are losing ground. In Greece, the picture is mixed with a high participation rate in STEM programs, but low performances. - STEM education is a pedagogical model based on interdisciplinary, the exploratory and experiential learning, teamwork, combinatory thinking and problem solving problems (Problem-based learning - PBL), with the students at the center. - SEV proposes, among other things, a coherent and long-term strategy with adaptation of syllabi, the strengthening of STEM teaching in initial and ongoing teacher training, the promotion of educational excellence and mobilization of business to support STEM education.

Science, technology, engineering, and mathematics (STEM) are fields of knowledge particularly important for the adaptation to this environment and a modern trend of educational systems is being formed emphasis on them, and on their effective teaching. It is a pedagogical model based on interdisciplinary, inquiry and experiential learning, teamwork, combinatorial thinking and problem solving (Problem-based learning - PBL), with students in epicenter. At the same time, skills are developed, such as methodological understanding, analytical thinking, creativity,

etc. That is, it faces to a large extent the various challenges they will encounter today's young people in their professional careers.

In the technologically developing economies of Asia, this approach has been adopted for decades. In contrast, Europe and North America have lost ground, as shown by the worsening student performance in mathematics and science - a consequence of low participation in studies of a positive and technological direction, as well as the limited encouragement of women to pursue technological professions.

In Greece, the picture appears mixed, with a high level of participation in tertiary STEM programs and balanced distribution of the sexes, but with alarmingly low performances in the positive and natural Sciences.

This weakness of the Greek education system undermines the long-term professional perspective of students and the development perspective of European and American businesses and economies (see indicatively here). SEV (Hellenic Federation of Enterprises) 's firm position is that in order for human resources to be the main strength production of innovation, we must cover the above major gaps in modern education in the country. In this direction, in addition to the detachment of school education from face-to-face teaching and the memorization of theoretical knowledge, with the main goal of admission to higher education, important it is also the acquisition, utilization and synthesis of knowledge. Despite positive steps such as the gradual inclusion of STEM in the educational agenda, and other efforts such as skill workshops, IT enhancement, etc. the country needs to significantly speed up the step towards modern and qualitatively upgraded STEM education, while at the same time the companies must place great emphasis on the development of their human resources. Education and upgrading the skills of all employees is a long-term investment for its development creativity, the growth of innovative capacity, and finally the extroversion in the global Buy. For the educational system, the challenge concerns how to integrate the above characteristics in the educational process, with which strategic planning, which educational content and which support in terms of teachers and logistical infrastructure.

Greek education system shows a significant lag over time in terms of convergence with the rest of Europe and effectively addressing the challenges of the 21st century, despite the ongoing reform efforts and the progress made in recent decades; mainly at the level of syllabi. Especially when it comes to STEM, except that an integrated national strategy for the promotion of STEM education, its structure, is absent educational system, the educational tradition, social and historical parameters do not facilitate the adoption and consolidation of the basic principles of STEM education, especially in secondary, general and vocational education. The negative effects of the ineffectiveness of the Greek educational policy reflected in chronically low student performance, especially in terms of level scientific and mathematical literacy of students who complete the compulsory education. In the latest PISA competition (2018), Greece ranks 45th out of 78 countries/regions, based on average student performance. This picture does not seem to be improving at high school.

Referring some useful Statistics about schools in Greece and in order to have a more objective view regarding the situation about the importance of STEM in education in Greece, most High Schools operate from 8am to 2pm, but there are also evening schools that operate from 7pm till 10pm for students – mainly adults – who work during daytime.

A variety of subjects are taught in Junior High Schools, including Modern and Ancient Greek Language, Maths, Physics, Chemistry, Geography, History, Physical Education, Religious Studies, Music and Art, while special emphasis is given to foreign language learning, as students are taught both English and another European language of their choice (students tend to choose between French and German). Students take exams in all subjects at the end of each school year.

Students may also pursue vocational training in Vocational High Schools, or, once they are 16, they may enrol in a Vocational Evening High School and graduate after 4 years of study. In addition, there are Vocational Training Schools; in these schools, as well as in all Vocational High Schools students attend general education courses combined with workplace courses. At the final stage of their studies, a student may work as an apprentice and gain valuable work experience.

High Schools offer a combination of General Education courses and Advanced Placement courses. Students who wish to pursue studies in Higher Education take Panhellenic exams in a specific number of Advanced Placement courses which fall into one of the following categories: Humanities, Science, Technology. This is considered to be a tough and highly competitive exam process that students go through in order to ensure education at a higher level 3.

The school laboratory of natural sciences (SEFE) covers the needs of natural sciences laboratory teaching. The implementation of lab activities is an integral part of teaching natural sciences subjects.

Students work in groups on a specific subject, developing their creativity in a spirit of cooperation. At the same time, they have at their disposal up-to-date instruments. The latter help them discover the environment and the laws that govern it. In order to offer extra support to lab teaching of natural sciences (Physics, Chemistry, Biology, Geology-Geography), laboratory centres of natural sciences (EKFE) operate. There can be one or more depending on the number of school units at each education directorate. Parallel to SEFE, all school units are equipped with a school laboratory for information technology and computer applications. Its function is to teach computer science and computer applications as defined by the curricula and the greater educational goals.

The lab operates complementary to the educational process. It offers a modern and interactive way of learning and training through the teaching of subject fields via:

1. The use of certified educational software

2. Pedagogical use of the Internet

3. The support of project-based learning in the framework of the school's activities

4. The European cooperation actions

5. The broadening of purely teaching activities (enhanced teaching, additional teaching support).

Additional comments:

• The teaching profession is highly attractive but opportunities and incentives to improve professionalism are lacking.

• Education expenditure is lower than in most EU countries and largely spent on salaries.

• Early school leaving has been further reduced, particularly in rural areas.

• Finding employment after education remains difficult, including for highly qualified people.

• Measures to tackle the brain drain of tertiary graduates are being implemented but

• internationalisation of Greek universities is underdeveloped.

The Directorate of Educational Technology and Innovation has invited again, in May 2023, Primary and Secondary Schools (public and private) to submit original material from educational visits-excursions, as well as material for the promotion of STEM and STEAM projects that are being developed or have already been developed by that's all.

Materials referenced in original educational field trips will include student texts of up to three hundred (300) words, photographs (up to five images per visit), videos (up to two videos per visit in the form of a link posted on an external channel), and artistic works (in image or video form, up to two per visit). Note that the material in question will be posted on the website: https://edu-gate.minedu.gov.gr/ in the Innovation category.

STEM and STEAM projects cross-curricular approach science, technology, engineering and mathematics. Their display material will include student texts of up to three hundred (300) words, photographs (up to five images per project), videos (up to two videos per project in the form of a link posted on an external channel) and artwork (up to two per project), which will also be posted on the above website (https://edu-gate.minedu.gov.gr) in the Innovation category.

Focusing on integration of STE(A)M in schools in Greece and presenting Good practices and ongoing national and international projects, resources, initiatives related to STE(A)M we continue presenting what is relatively new regarding STEAM is the part of the Arts being embedded with Science, Technology, Engineering and Mathematics (STEM) and brings the STEM together with Arts (STEAM). Therefore, this addition is introducing students and educators a more holistic approach in the classroom that involves inquiry, innovation and critical thinking. Teachers in Greece have been trying to motivate the students in order to think of STEAM education and the connection of STEAM education and Greek ethnicity. STEAM is developed to

integrate STEM scientific subject categories into various relevant disciplines for education.

These constructed programs aim to teach apprentices to think critically and use engineering, technology, natural sciences in virtual designs or creative approaches to real-world problems while building on them mathematics and science base. Thus, STEAM programs add Art to STEM curriculum by depicting on design principles and heartening and invigorating creative solutions.

In other words, it introduces students and educators to a holistic approach in classroom. STEAM removes limitations and replaces them with wonder, critique, inquiry, and innovation. Considering the importance of helping pupils understand that STEAM education is connected to everyday life, teachers in Greece need to motivate the students in order to think of the interdisciplinary of STEAM education and more specifically, the connection that may exist between STEAM education and the Greek culture. In other words, pupils have to cooperate in an interdisciplinary way during discovery, inquiry and experiential learning activities.

STEAM rises up STEM to the next level: it provides students to network their learning in these critical areas together with arts concepts and practices, design principles, and standards in such a way to provide the whole floor of learning at their disposal.

STEM or STEAM alone miss several key components that lead to the feasible holistic approach, that many employers, educators, and parents have voiced as critical for students to thrive in the present and rapidly approaching future. STEM integrated with arts and culture could offer such miss and develop to an educational approach to learning that uses of Science, Technology, Engineering, Mathematics in Arts and Culture as access points for guiding student inquiry, intercultural dialogue, critical thinking, understanding, realization of a common language; that of STEM. The end results are students who take thoughtful risks, engage in experiential learning, persist in problem-solving, embrace collaboration, and work through the creative process.

The text right below focuses on some of the initiatives taken in Greece, the best practices, and the sustainability of their actions in National level:

1. Hellenic Education Society of STEM

An example of the national level initiatives regarding the national level is the Hellenic Education Society of STEM

Target group: students, parents, teachers

Aims: The aims and objectives of the E 3 STEM are to: provide best teaching and learning practices and concepts for the operative delivery of STEM in Education didactics models; provide applied teaching projects/didactic scenario and curriculum activities; provide material towards the clarification of the concepts “STEM in Education” and “STEM epistemology”; promote the implementation of “engineering pedagogy” in Education integrated in STEM Education; provide guidance through the support of STEM based laboratories; provide innovative ideas for implementation of “STEM in education” in curriculum models; create and sustain a national professional

association representing the educators in STEM in Greece; preserve and deliver a representative national opinion for member associations; provide a common forum for educators in STEM education at National and International level; cooperate with other organizations and stakeholders at local, national and international levels; facilitate and provide strategies for the dissemination STEM epistemology and practices for the teaching and learning process at local, national and international level.; provide support for member associations; organize and conduct workshops, conferences and seminars; be involved in National, European and International projects; publish publications with an International focus; increase community awareness of STEM epistemology; provide a repository with “STEM in Education” learning design activities

Resource and activity: Membership provides access to material, training, advice and support. (E3STEM), can support and represent those in the foundation years of their career as teachers and it runs by providing seminars and workshops to students and schools.

Teaching strategies: The Hellenic Education Society of STEM engages in the development of STEM applications and epistemology with practices linked to the Inquiry Based teaching and learning approaches. It aims to promote the STEM epistemology, computing, computational science and computational thinking, and to advance understanding and education of the STEM methodology alongside with contemporary learning theories and didactic models. It is the only professional body for STEM education in Greece with the vision to grant chartered status to STEM in Education professionals.

Procedural information: the Hellenic Education Society of STEM was first created back in 2017 and is an independent, non-profit, registered professional body and its members work for STEM education in primary, secondary and tertiary education. It is a community of University Professors, School educators and School Advisors who share a common vision for the role of STEM epistemology in promoting education.

2. MAthisi STEM Camp at Moraitis School

Mathisi Initiative is a not-for-profit organization dedicated to introducing innovative and recognized educational programs in Greece in an open and affordable way. It is supported by foundations and private donors. For the summer 2019, it collaborated with the MIT Jameel World Education Lab (J-WEL) to establish an MIT-supported STEM Camp for the first time in Greece (and in Europe) at the Moraitis School in Athens.

While we haven't been able to run and expand our scheduled 2020 camp due to Covid-19, we are pursuing our work to be back with adaptative programs in the near future.

Target Group: pre-high school students (12- to 14/15 -year old children)

Aims: provide pre-high school students with local and affordable access to programs of internationally recognized excellence and relevance, to foster independent and

curious learners, critical and creative thinkers, and problem-solving young adults engaged in the world.

Resource and Activity; The 2019 Mathisi Camp took place at the Moraitis School in Athens, with the participation of 60 students from 1st, 2nd and 3rd Gymnasium, coming from 20 different schools. The program cost for 2 weeks was €650 and almost a quarter of the students received financial support. Buses were provided along main routes.

3. CTY Greece – Center for Talented Youth at Anatolia College

CTY Greece at Anatolia College is the culmination of the strategic partnership of three organizations with a long tradition in education and social contribution. Anatolia College, Johns Hopkins University in the US and the Stavros Niarchos Foundation, all came together to establish a center that is unique to Greece and Southeastern Europe in general.

Target Group: primary and secondary education students

Aims: The program aim offers summer programs that provide the eligible students the opportunity to engage in challenging academic work in the company of peers who share their exceptional abilities and love of learning. As part of the Older Students Summer Day Programs, students enrich their experiences inside and outside the classroom. At CTY Greece the main components of the program's educational experience are both learning and cultivating social skills, as students develop lifelong friendships. The courses are fast-paced and have high academic requirements, so that they meet the needs of the respective high academic potential children they are serving. The students come from different places and have different educational experiences. For three weeks they are invited to delve into their academic interests while being part of an extraordinary community, without distractions.

2 Presentation of examples for existing practices in teaching STEM in Greece

Despite the absence of a comprehensive STEM strategy in Greece, recent years have seen development important initiatives to promote STEM education at all levels, mainly but in secondary general education, and more systematically, in private secondary education.

Although these are, as a rule, isolated and piecemeal actions, the value and their impact on the educational and student community, but also on Greek society as a whole, are extremely important, as on the one hand they increase students' interest in these subjects scientific areas, on the other hand they gradually introduce STEM teaching in schools.

In in the majority of cases, these actions are implemented with the assistance, or even with initiative, of some private enterprise or organization, such as, for example,

the strategy Cosmote's collaboration with the Greek branch of the Educational Robotics Organization and of Science (WRO Hellas), Vodafone's Generation Next Program.

The activity of the teachers individually and collectively is also noteworthy level. Indicatively, the relevant initiatives of the Hellenic Scientific Union are mentioned STEM Educators (E3STEM), the Union of Greek Physicists, the Panhellenic Union of Teachers of Informatics (PEKAP) but also of the Open Technologies Organization (EELLAK) mainly through its participation in the Scientix European Network.

And in the field of politics, there is a tendency to strengthen STEM in education. According to current approach of the Ministry of Education, STEM is now gaining a place in education agenda and the first reform efforts have begun to materialize, at least at the institutional-regulatory level (e.g. skills workshops, IT support in analytical programs etc.). However, it is necessary for the country to open up and accelerate its pace in everything the issues pertaining to the national skill development ecosystem in order to maximize the contribution of human resources to economic growth and productivity transformation. Strengthening STEM across the spectrum of the education system is a necessary component for the modernization and upgrading of Education.

2.1 Presentation of best practice 1: Introduction to electronic technology

Name of providing Learn STEM partner	IEK KAVALAS
Title/Name of the example	Introduction to electronic technology
Organization, country and website	Educational Robotics and Science Organization (WRO Hellas), Greece, https://stem.edu.gr/en/
Brief description (abstract)	The world of electronics is significantly influencing the environment in which we live. It is critical for children to understand basic electronic principles so that they have control over the technological environment around them and can make smart decisions. Basic electronics principles are not taught in the school curriculum. STEM Education's proposed program fills this void in an interesting and entertaining way. How do a processor and its memory work, and how do they differ? How do device power supplies work, and what are the key elements by which we choose them? How do LED, neon, and fluorescent lights work, and how do we select a bulb? What antennas are used for wired and

	wireless data transmission? How are color and sound converted into data, and how are images and video displayed on screens? These are some of the questions that will be answered during the program's fun activities. Objectives On completion of the program, students will have: ➢ become familiar with the basic principles of electronics, ➢ created their own circuits to investigate the concepts of the project, ➢ developed critical thinking and expertise about electronic devices they use in their everyday lives, ➢ answer real-world questions according to the STEM methodology. Number of courses: 30 Duration: 90′
Age range	Secondary School
Subject/discipline or crossdisciplinary	Engineering

2.2 Presentation of best practice 2: Future Innovators

Name of providing Learn STEM partner	IEK KAVALAS
Title/Name of the example	Future Innovators
Organization, country and website	Educational Robotics and Science Organization (WRO Hellas), Greece, https://stem.edu.gr/en/
Brief description (abstract)	The Future Innovators program consists of a series of projects that students will implement, thus understanding genuine problems and providing innovative solutions using cutting-edge technologies. These include technologies such as 3D design and printing, cloud computing, machine vision and artificial intelligence. Through this program, students learn to design structures and parts of robotic systems in 3D applications, select and assemble the appropriate electronic parts (sensors, actuators, microcontrollers) and code using advanced practices and algorithms. They are also introduced to types and characteristics of data

	networks, as well as to concepts and methods from the field of artificial intelligence. At the same time, they develop communication skills by preparing presentations on their creations. Objectives On completion of the program, students will have: ➢ deepened their knowledge of cutting-edge technologies (robotics, artificial intelligence, etc.), ➢ programmed complex applications by creating algorithms with a high degree of complexity, ➢ designed and fabricated artifacts with 3D design and 3D printing, ➢ develop presentation, problem-solving and innovative thinking skills through the project process. Number of courses: 30 Duration: 90′
Age range	15-18 years old
Subject/discipline or crossdisciplinary	Engineering, Technology

2.3 Presentation of best practice 3: Educational Robotics

Name of providing Learn STEM partner	IEK KAVALAS
Title/Name of the example	Educational Robotics
Organization, country and website	Sparmatseto, Greece, https://sparmatseto.gr/events/kavala-ekpaideftiki-robotiki/
Brief description (abstract)	Educational robotics has built a solid base of theoretical, epistemological and practical principles that allow it to act autonomously as a means of education adapted to the particular principles of exploratory learning characteristic that makes it highly effective. We will get in touch with educational robotics, its theory and its materials. We will explore her wonderful world, build and program robotic structures that will create art. All this with the ultimate goal of knowledge and artistic awareness of the participants. Purpose and Objectives The purpose of the program is to provide knowledge, skills and experiences regarding educational robotics, its methods, the applications it can have and its effectiveness. At the same time it is sought to provide the

	appropriate background which is necessary to engage the participants in a highly effective through training. The goal of the program is to equip children with all the cognitive, methodological and practical skills that will allow them to delve into educational robotics, understand it and apply it by gaining useful experiences and mastering knowledge through robotics.
Age range	14-15 years old
Subject/discipline or crossdisciplinary	• Physics (motion, friction, energy, pressure, forces, etc.) • Mathematics-Geometry (proportions, sizes, perimeter, angles, etc.) • Engineering (construction, assembly, stability, etc.) • Programming (sensors, algorithmic perception, digital intelligence, etc.)

2.4 Presentation of best practice 4: R-Lab. Εργαστήρι Physical Computing

Name of providing Learn STEM partner	IEK KAVALAS
Title/Name of the example	R-Lab. Εργαστήρι Physical Computing
Organization, country and website	Robomatheia, Greece, https://robomatheia.gr/
Brief description (abstract)	Learning the secrets of the Internet of Things (IoT) This educational program introduces students to new trends in computer science and communication, equipping them with high-level skills. Students will learn to program computing devices and become familiar with sensors and electromechanical structures (IoT), solving everyday problems using robotic automation, thus connecting computers with the physical world (Physical computing). Objectives: ➢ Cultivating algorithmic thinking. ➢ Development of imagination and creativity. ➢ Improving self-esteem and confidence. ➢ Analytical and Synthetic Thinking - Formation of Critical Thinking. ➢ Cultivating a collaborative spirit and communicative clarity. ➢ Searching for information and acquiring new knowledge. ➢ Search and find solutions to real, everyday problems.

	➢ Innovation - Familiarity with the possibilities and applications of new technologies. ➢ Incorporating school material in an experiential way. 60 min / week
Age range	12-19 years old
Subject/discipline or crossdisciplinary	Science, Computer science, Arduino, Raspberry Pi, micro:bit

3. Final comment

The above information demonstrate the overall and timeless weakness of Greek education system to effectively impart knowledge and develop critical life skills, such as critical thinking, problem solving, self-management, etc. This negative image is due to a variety of combined factors. Despite her scientific proficiency of the majority of human resources employed in education is not disputed, reservations are expressed, regarding the pedagogical competence of the teachers, especially in secondary education.

Mainly at the didactic level, school education remains attached to the frontal teaching and memorizing theoretical knowledge, primarily aiming at access to higher educational levels, without any real concern for the acquisition of knowledge and development of corresponding skills and abilities. As with all centrally controlled, bureaucratic, systems, in the Greek school the teacher exercises his function within an introverted school environment. Faced with a variety of administrative and practical limitations and without substantial support - beyond the supplies he acquired during the initial education (which often lacks pedagogical content) and his personal conscientiousness - the Greek teacher exercises his function in conditions very different from those that apply to foreign teachers, with whom it is nevertheless compared systematically.

At the same time, the suffocating and conservative framework of the analytic programs, the intensifying student heterogeneity of the class, the bureaucratic system of governance, its weaknesses evaluation system of students, teachers and school units, its declining prestige of the teacher's profession and the absence of motivation for professional development and self-improvement, society's conservative perception of Education, its inadequacy and discontinuity of educational policy, constitute an environment that acts as a deterrent towards it adopting the critical components of STEM education.

In contrast to these negative findings, Greece shows a comparatively high level participation in higher education STEM degree programs, leaving behind some of the most economically and technologically developed countries. It is relatively positive the image of the country and regarding the participation of women in STEM. Besides, the girls' academic performance, in the specific fields, does not differ significantly

from that of men/boys. In the case of EPALs, in fact, the average score in all STEM fields is stable 1 unit higher than that of boys, although generally significantly lower in STEM EDUCATION relation to classical or theoretical courses (language, history, etc.).

The national education policy must capitalize on the comparative advantage of the increased interest of young people, men and women, for positive and technological career options direction. An overall improvement in the quality of school education in the direction is required strengthening of scientific and technological literacy, already from the first grades school. Achieving this goal requires a change in the educational model, with greater emphasis on interdisciplinary, practical application and the cultivation of contemporary skills, and stronger interconnection of education with society and the economy, so that the students to understand experientially the importance of science and technology in real world.

Equally important is the redesign of the higher education map education in the direction of increasing enrollment in STEM degree programs, but and strengthening the provision of STEM educational pathways at lower grades, especially of Vocational Education and Training, so that even more young people can are directed to corresponding study programs.

As a final conclusion, what the country needs most is an integrated national strategy for the quality upgrade of the education provided, to all degrees, with a particular emphasis on STEM fields.

Resources:

- https://www.britannica.com/place/Greece/Local-government#ref26469
- https://www.worldometers.info/demographics/greece-demographics/#pop
- https://www.fulbright.gr/en/study-in-greece/the-greek-educational-system
- https://eacea.ec.europa.eu/national-policies/eurydice/content/teaching-and-learning-general-lower-secondary-education-16_en
- https://ec.europa.eu/education/resources-and-tools/document-library/education-and-training-monitor-2019-greece-report_en

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Learn STEM

Innovative Model of learning STEM in secondary schools

ERASMUS+ KA220
Cooperation partnerships in school education

Overview on existing practices in teaching STEM through innovative pedagogical approaches for Romania

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Date:
30.08.2023

Reference Number:
2022-1-TR01-KA220-SCH-000087583

Content

1 The importance of STEM in Educational contexts

STEM education plays a crucial role in the development of education in Romania and offers numerous benefits for students, society, and the economy.

Firstly, promoting STEM education prepares students for the modern world, which relies on technology and innovation. By learning sciences, technology, engineering, and mathematics, students develop critical skills, analytical thinking, and the ability to solve complex problems. These competencies are essential in a digital and ever-changing era.

Furthermore, STEM education meets the demands of the job market and the modern economy. With a well-prepared STEM workforce, Romania can attract foreign investments and develop innovative industries. Graduates with expertise in this field are sought after in various sectors, such as IT, engineering, healthcare, and scientific research.

In recent years, traditional learning methods have increasingly burdened the didactic process, causing students to lose interest in learning crucial concepts simply because they are not attracted to the way they are presented. Interdisciplinarity is crucial in today's world, and through STEM education, all information will be processed without being seen as "useless knowledge"

By developing these skills, Romania can progress in key areas such as information technology, renewable energies, artificial intelligence, and medical technology. This progress can lead to improved quality of life, health, and environmental protection.

STEM education also promotes creative and innovative thinking. Students are encouraged to explore, experiment, and develop their original ideas, thus becoming better prepared to solve complex challenges using innovative solutions.

Additionally, high-quality STEM education can contribute to reducing social and economic disparities. By providing equal access to STEM education, we can increase the chances of success for all students, regardless of their background or social origin.

2 Presentation of examples for existing practices in teaching STEM in Romania

The four selected examples of best practices are BRD FIRST Tech Challenge, TechnoBrick, CODE Kids, and Programing with Patience. These initiatives promote STEM education in Romania, offering students interactive learning opportunities in the fields of science, technology, engineering, and mathematics. BRD FIRST Tech Challenge and TechnoBrick focus on innovative domains such as engineering, mechanics, mathematics, informatics, physics, entrepreneurship, robotics, and environmental protection, while CODE Kids and Programing with Patience introduce students to programming, computer science, mathematics, Ethernet networks, game-based learning, artificial intelligence, graphics, and mobile applications. Through these innovative practices, STEM education in Romania is improved, preparing students for a tech-driven world and fostering the development of innovative skills.

2.1 Presentation of best practice 1: BRD FIRST Tech Challenge

Brief overview

The BRD FIRST Tech Challenge is the largest robotics competition for high school students in Romania and Europe. Students aged 13 to 18 participate in cross-disciplinary STEM areas like engineering, mechanics, mathematics, informatics, physics, entrepreneurship, and robotics. Today, through this project, over 3000 high school students and 400 mentors from 73 cities in Romania are participating in building a competition robot from scratch, using innovative educational methods.

BRD FIRST Tech Challenge 2023, organized by the *Asociația Nație Prin Educație* (*Nation Through Education Association),* in partnership with BRD Groupe Société Générale, is the largest robotics competition for high school students in Romania and Europe.

This competition adheres to the values of the international organization FIRST and, in addition to helping students develop their technical skills and strengthen their education in the fields of STEM, entrepreneurship and robotics, it opens a door to their future.

At this competition, can participate students aged between 13 and 18 years . The subject/discipline or cross-disciplinary areas include engineering, mechanics, mathematics, informatics, physics, entrepreneurship, and robotics.

Last year, the World Championship was won by a team from Romania, namely the Delta Force team from Arad.

BRD FIRST Tech Challenge means more than robots – it is an engineering project and work organized as in a startup, which involves work, dedication and above all teamwork, a vital requirement for a robotics team.

The Nation Through Education Association has offered support, materials and financial resources for robotics teams in Romania throughout these years. Through their efforts, today over 3000 high school students and 400 mentors from 73 cities in Romania are building a competition robot from scratch, through innovative educational means.

From the first edition in 2016 until now, BRD Groupe Société Générale has facilitated the participation and education of over 13,000 students and over 2,000 teachers in STEM & entrepreneurship education.

A team from Iași county, the PEPPERS Team, from the Grigore Moisil Informatics High School, also qualified in the first three best performing teams from the national stage in 2023, and represented Romania at the World Championship in Houston, USA.

The creativity and passion of the Peppers team members reached another level in this competition, through which the students developed practical and engineering skills, as well as the ability to promote, understand, and critically analyze all situations they encountered.

In the competition, the robot created by the Peppers team had the task of lifting cones of two different colors and positioning them on poles of 35, 60, and 85 centimeters. The robot has a silicone gripper at the front to grasp the cones, a sliding mechanism with sprockets to lift the cones at each required level, and a mechanism to place them in front or behind, keeping them perpendicular to the ground at each step to maintain their orientation. Everything is controlled by two controllers operated by two drivers who perform different actions. One driver controls the robot's movement on the field and the gripper, while the other handles the lifting mechanism.

Most of the robot is 3D printed, but they also used parts purchased from distributors in the United States.

As a result of their participation, the Peppers Robotics Team from "Grigore Moisil" Theoretical High School of Computer Science in Iasi achieved the second place in the „Motivate" category.

For more information about this competition, you can access the official website of the „Natie prin Educatie" (Nation Through Education) Association: https://natieprineducatie.ro .

Image Source: https://natieprineducatie.ro/season-2-day-3/mfw_3606/

2.2 Presentation of best practice 2: TechnoBrick

Brief overview

TechnoBrick is a project that facilitates the understanding of science through non-formal activities using LEGO® Education sets. Participants, aged 12 to 18, build mechanisms to put theoretical knowledge into practice. During the four editions of TechnoBrick, over 500 students from Iași county participated, developing technical skills and teamwork while learning about environmental awareness and responsible consumption.

The Alegoria Association was founded out of the desire to offer young people innovative methods to explore through play and practical activities in the fields of STEAM (Science, Technology, Engineering, Art, Math).

One of the projects of the Alegoria Association in which 7 volunteers are currently involved is TechnoBrick.

The aim of this project is to facilitate the understanding of science through non-formal activities made with LEGO® Education building sets. Exploring the fields of STEM can be interactive and even fun, using LEGO® Education sets facilitating the development of both technical skills and social skills of teamwork, cooperation and creativity precisely because students have the opportunity to build various mechanisms thus putting theoretical information into practice.

In the first two editions, participants experienced how to apply physics concepts in a practical way, not just on paper. Students played with pieces and circuits, assembling various constructions using LEGO Education sets.

Under the guidance of facilitators, students built inclined planes, sprockets, and machines. With their help, they explored physics principles such as friction and weight and then solved several challenges.

The third edition of TechnoBrick had the main theme: Autonomous machines versus human-driven machines.

Thus, in the third edition, 92 students aged between 14 and 18, from four high schools in Iași county, participated in a series of engineering and robotics workshops, experiencing an interactive learning method by playing with LEGO® pieces. The activities aimed to understand concepts of physics, mechanics, mathematics, and computer science related to the functioning of machines.

Students built machines from LEGO® Technic pieces and programmed robots with LEGO® Mindstorms to explore the features, similarities, and differences between autonomous machines and manually-driven ones, by humans.

Among other things, they discovered how light and color sensors help keep the machines on track, and the gyroscope sensor aids in proper parking of the car.

The emotions of the drivers who controlled the cars through remote control had an impact on the travel times, as they increased due to the human factor, while the autonomous cars

encountered no issues, thus demonstrating the importance of possessing programming knowledge.

In the last edition of TechnoBrick, the one with number four, the proposed theme was Waste collection and selection automation systems.

Four practical workshops were organized during which the participants build using LEGO Technic pieces, sensors and autonomous mechanisms programmed through LEGO Mindstorms systems and machines to exemplify and understand some principles of sorting and recycling different types of waste. The methods are interactive and value both the understanding of the sciences and the development of personal skills, such as teamwork and presenting one's own results in public. Also, students are trained to be aware of the importance of selecting and recycling waste, but especially of responsible consumption and the fact that it is easy for each person to implement small actions that contribute to protecting the environment.

Throughout the four editions of TechnoBrick, the subjects or disciplines covered included mechanics, mathematics, informatics, physics, and environmental protection, either individually or in crossdisciplinary combinations.

The age of the participating students in TechnoBrick's activities ranged from 12 to 18 years old.

During the four editions of TechnoBrick, more than 500 students from several high schools in Iasi county participated.

For more details about the TechnoBrick project and The Alegoria Association initiative, you can visit their website: https://technobrickiasi.wordpress.com/

Image Source: *https://technobrickiasi.files.wordpress.com/2019/02/tb3a.jpg*

2.3 Presentation of best practice 3: CODE Kids

Brief overview

The CODE Kids project aims to foster a coding and STEM movement in rural and small urban areas. Through partnerships with public libraries and community institutions, CODE Kids provides training and workshops to develop digital skills in children aged 10 to 14, encouraging community involvement and potential tech careers.

CODE Kids is the project of the Progress Foundation, awarded in 2022 in Brussels at the Emerging Europe Awards competition with the top prize in the Future-proof Education category

Progress Foundation is a non-governmental organization, founded in 1996 in Bistrita, Romania, which contributes to the development of community institutions, vulnerable individuals and groups and helps people become more empowered through education, technology, research and innovation.

The organisation supports people to evolve, realise their potential and achieve well-being in sustainable and resilient communities. Through its partnerships, Progress Foundation focuses on facilitating lifelong learning, transferring innovation, building IT and STEM skills, and developing new methodologies for participatory design and social inclusion.

In achieving its goals and reaching every social group the organization uses public libraries and community spaces in villages and towns as focal points for learning and centers for social innovation. www.progressfoundation.ro

The CODE Kids project aims to create a coding and STEM movement where children, young people, librarians and volunteers from rural and small urban areas develop their digital skills and get involved in the life of the community they come from by solving creative digital tasks.

In the CODE Kids project, students will undergo IT courses, develop animations, and create applications. In addition to the courses, they will have practical electives and competitions.

Beyond programming skills, students will also have the opportunity to explore hardware. Through hardware-related activities, they will gain knowledge of how technological components function, how they can be assembled to create various devices, and how they can integrate them into their coding projects. They will understand the connections between software and hardware and learn how to create applications and programs that efficiently communicate with physical components.

By combining coding activities with learning about hardware components, students will benefit from a comprehensive educational experience, developing their skills in both domains and preparing themselves to become technological creators and innovators in the future.

Public libraries have a central role in the CODE Kids project, as they are often the only institutions that provide computers and internet connection for children and young people.

Through the training activities and organized workshops, another way is opened to explore the digital world with its opportunities for development and learning, so that more than 4600 children between the ages of 10 and 14, are encouraged to get actively involved and even follow a career in technology.

Public libraries, NGOs, town halls and other community institutions from 33 counties of Romania are or will become strategic partners of the project, directly involved in its implementation, through the staff employed and the premises owned.

Starting from 2021, the doors to new perspectives are open.

The first programming clubs for children began to form outside public libraries, under the coordination of volunteers from various fields of activity.

Under the umbrella of a new slogan „Program the future of your community", the CODE Kids project aims to reach as many rural and small urban communities in Romania as possible.

CODE Kids offers crossdisciplinary education in computer science, ethernet networks, and game-based learning, providing children aged 10 to 14 with a dynamic and enjoyable approach to exploring technology.

For more details about the CODE Kids project and the Progress Foundation, you can access the website: http://www.codekids.ro

Image Source: https://www.freepik.com

2.4 Presentation of best practice 4: Programing with patience

Brief overview

„Programing with patience" is an EduSoft Association initiative that fosters programming education for children and youth aged between 7 and 24 through STEM disciplines. Launched in 2018 and expanded nationally in 2019, it currently involves over 800 active participants. The project's commendable activities in the last two years earned it the „Merit Award" at WCIT, highlighting its commitment to excellence in computer science, mathematics, Ethernet networks, game-based learning, artificial intelligence, graphics, and mobile applications.

„Programing with patience" is an initiative of the EduSoft Association, which promotes STEM education among children and youth.

The project started at the end of 2018 and was carried out by the EduSoft Association in collaboration with the "Gheorghe Vrănceanu" National College from Bacău and various organizations that support IT education.

The aim of the project is to attract more middle school and high school students to the study of informatics, by approaching interesting topics, in an interdisciplinary and less formal way.

In the first year of the project, more than 300 students from Bacău and its surroundings were enrolled, of which 80-140 students regularly attended each meeting. Starting in 2019, "Programing with patience" project was extended to the national level, taking place in several local centers (Bucharest, Iași, Timișoara, Galați, etc.).

Now the number of active participants in the project exceeds 800 children.

„Programming with patience" attracts children and young people to computer science, offering them a more secure future. Students learn how to create complex games and apps, program robots, have fun together and exercise.

Unlike classic lessons, lessons in the „Programming with patience" program are interactive and address current topics such as artificial intelligence, graphics, mobile applications, using modern and accessible programming languages.

Those from „Programming with Patience" have classified their centers into four categories based on the students' inclinations and objectives. Promoting inclusive education, the EduSoft Association believes that these 4 categories of centers (including the students and their teachers) should not necessarily be considered in a hierarchical order.

Category A: In these centers, students are primarily taught algorithmic elements using standard programming languages (such as C, C++, Pascal, Python, Basic, Java, including Visual Studio environment, etc.).

Category B: In these centers, students are primarily taught algorithmic elements using standard programming languages (such as C, C++, Pascal, Python), and they are interested in

understanding the concepts from school programs, as well as those for baccalaureate and university admission.

Category C: In these centers, students are primarily taught introductory elements of programming using visual programming languages or programmable platforms (such as Scratch, Alice, Blockly, Microbit, Arduino, Raspberry Pi, etc.), and they are interested in understanding the basic concepts of programming by creating animated stories or graphical games.

Category D: In these centers, students are not extensively taught programming notions; instead, they learn elements of information technology, which may tangentially touch on programming elements. For example, these centers may cover web design, introductory elements of robotics, computer graphics (including photo-video processing, CAD, or animation).

Moreover, students from all centers have the opportunity to meet exceptional teachers, university professors, as well as young individuals who have succeeded in the IT field, either as employees or as scholarship recipients in companies like Google, Amazon, Facebook, Twitter, Palantir, Bitdefender, etc., or have outstanding academic activity. They share their experiences with computer science and their current interests in the IT field, and also teach some more advanced topics less covered in the school curriculum.

During the World Congress of IT (WCIT - World Congress on Information Technology which took place in Penang-Malaysia), the Computer Science Project „Programming with patience" was nominated in the "Opportunity / Digital Inclusion" category and received the „Merit Award" as a recognition of the success of the activities carried out in the last two years.

For more information about the "Programare cu răbdare" project and EduSoft Association, you can access the website: https://programarecurabdare.ro/

Image Source: https://www.freepik.com

3 Final comment

These were just four of the initiatives implemented in Romania in the field of STEM. Recently, in Romania, there has been a growing emphasis on adopting more innovative teaching methods and integrating extracurricular and interdisciplinary activities to attract students to subjects they might be hesitant about. By involving students in STEM-related activities, they can gain a clearer understanding of concepts that were previously difficult to grasp through traditional approaches. These endeavors are fostering a stronger comprehension and admiration for STEM disciplines, inspiring students to explore and engage with science, technology, engineering, and mathematics.

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Learn STEM

Innovative Model of learning STEM in secondary schools

School Education ERASMUS+
KA220-SCH -
Cooperation partnerships in school education

Overview on existing practices in teaching STEM through innovative pedagogical approaches for Germany

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Date:
16.08.2023

Reference Number:
2022-1-TR01-KA220-SCH-000087583

Co-funded by the European Union

Content

1 The importance of STEM in Educational contexts

STEM subjects, or MINT in German, have been the focus of education at all levels for several years now. Education leaders are aware that advancing STEM subjects, and with them building the knowledge and skills, are key necessities to ensure the country´s long-term prosperity. The STEM subjects are key drivers of research and development, and therefore young professionals are needed in these sectors in the long term.

In Germany, the Federal Ministry of Education and Research has developed an action plan in order to promote STEM in all educational sectors (kindergarten, school, university and further education) (BMBF, 2022). It foresees different offers in STEM subjects like participating in challenges or research activities. The Ministry would also like to strengthen programmes which combine school and out of school activities because they see the chance to improve STEM competences in these kinds of programmes. These programmes should have game-based approaches, so learners will get a playful experience.

In order to develop STEM programmes, the Ministry supports a community platform which brings together all sorts of stakeholders, like professionals, learners, families, companies etc. It appears that out of school places are the right places for young people to get to know STEM without feeling the pressure of school. They get the chance to develop their own ideas into real projects with research and professional preparation.

Still, teaching is of course a main aspect in promoting STEM. Therefore, German schools have been coming up with excellent programmes.

Source: BMBF/Bundesministerium für Bildung und Forschung (2022). MINT-Aktionsplan 2.0. Retrieved from: https://www.bmbf.de/bmbf/de/bildung/digitalisierung-und-mint-bildung/mint-bildung/mint-aktionsplan_node.html

2 Presentation of examples for existing practices in teaching STEM in Germany

In Germany, there has been a drive to promote STEM subjects for many years. Over the years, fascinating projects, networks, programmes and ideas have developed, as the following four best practice examples will show. From so-called STEM schools to student research centres and nationwide networks, there are numerous best practice examples from Germany, only four of which are presented below.

2.1 Presentation of best practice 1: MINT in Spee

In Paderborn, a secondary school called Friedrich-Spee Gesamtschule Paderborn has got a certificate for being a STEM school. One of their recent practices was a challenge in which learners needed to come up with a possibility to heat water without electricity. Four boys came up with a great idea and won the challenge. They had the chance to work on their idea and try things out in their free time for a whole school year. The school owns its own laboratory for learners.

https://www.speepb.de/schulprofil/mint/mint-schule/

These schools play a crucial role in cultivating a robust foundation in STEM disciplines among students. The platform underscores the significance of fostering a comprehensive learning environment that promotes active engagement in STEM activities, enabling students to develop essential skills, knowledge, and a genuine passion for these fields.

The core essence of the platform revolves around the concept of STEM schools and the enriching opportunities they provide to students. STEM schools are dedicated to creating an immersive educational experience that goes beyond traditional classroom learning. The platform accentuates the idea that STEM schools serve as catalysts for inspiring students to explore the realms of science, technology, engineering, and mathematics through hands-on projects, interactive workshops, and collaborative initiatives.

These schools, as Friedrich-Spee Gesamtschule Paderborn, create activities which are thoughtfully designed to ignite curiosity, stimulate critical thinking, and encourage problem-solving skills among students. From conducting scientific experiments to coding and robotics workshops, students are offered a dynamic platform to delve into practical applications of STEM concepts. Such activities not only deepen students' understanding of complex STEM subjects but also cultivate important skills such as teamwork, communication, and creativity. By actively engaging in projects and activities that mirror real-world challenges, students are better prepared to navigate the ever-evolving landscape of STEM professions.

The example of Friedrich-Spee Gesamtschule Paderborn and their challenge also emphasizes the role of educators in STEM schools. It showcases how teachers and mentors play a pivotal role in guiding students through their STEM journey, fostering

an environment of exploration and innovation. The school also provides professional development opportunities for educators to enhance their STEM teaching methodologies and keep pace with the latest advancements in the field.

Source: Screenshot from https://www.speepb.de/schulprofil/mint/mint-schule/ on 16th August 2023

2.2 Presentation of best practice 2: Schülerforschungszentren (Student Research Centers (SRCs))

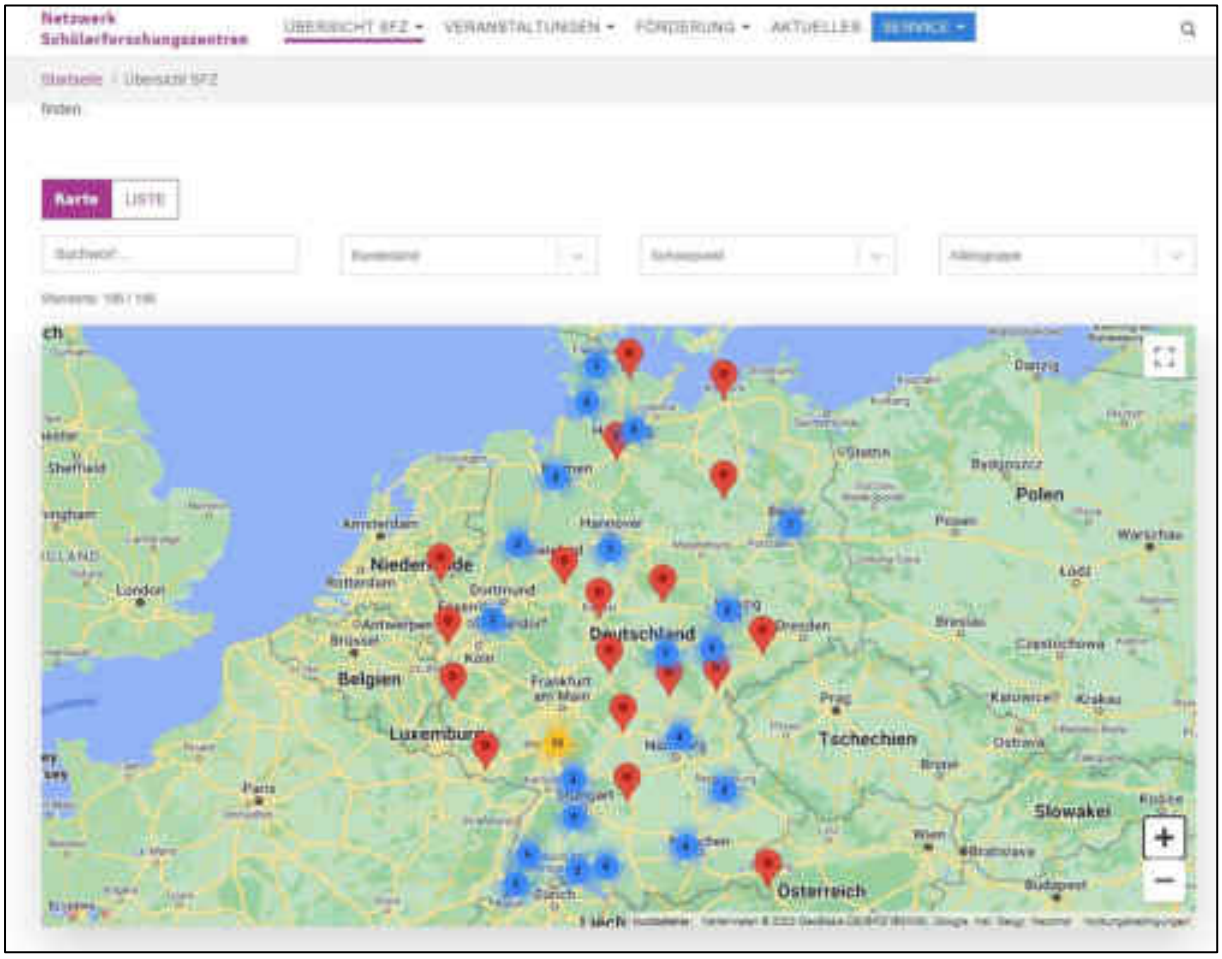
Schuelerforschungszentren is a comprehensive platform that centers around the concept of Student Research Centers (SRCs) in Germany. SRCs are specialized institutions that are dedicated to fostering a culture of scientific curiosity and inquiry among secondary school students. These centers play a pivotal role in nurturing the spirit of exploration and innovation in young minds, ultimately contributing to the development of a well-rounded STEM (Science, Technology, Engineering, and Mathematics) education landscape in the country.

The essence of Schuelerforschungszentren lies in its commitment to promoting and supporting SRCs across Germany. These centers act as hubs for students eager to delve deeper into the realm of scientific research. They offer a dynamic environment where students can engage in hands-on experiments, collaborative projects, and investigative studies under the guidance of experienced mentors and educators. Through these initiatives, students are empowered to explore their scientific interests, develop critical thinking skills, and cultivate a genuine passion for STEM subjects.

One of the core objectives of the platform is to connect like-minded individuals and institutions that share a common goal of advancing student research and scientific exploration. Schuelerforschungszentren serves as an invaluable resource for educators, administrators, and stakeholders interested in establishing and nurturing SRCs. The platform offers a wealth of information, ranging from best practices and guidelines to success stories and case studies from existing SRCs.

Furthermore, the platform underscores the importance of providing students with access to state-of-the-art laboratories, equipment, and resources that might not be readily available in traditional school settings. By offering a conducive environment for experimentation and inquiry, SRCs contribute significantly to students' academic growth and their eventual career pathways in STEM fields.

In essence, SRCs serve as a hub of inspiration and information for all individuals invested in promoting student-driven scientific research and discovery. It encapsulates the collective efforts of educators, researchers, policymakers, and students who recognize the significance of nurturing a generation of inquisitive minds. Through this platform, the transformative impact of Student Research Centers on the educational landscape of Germany continues to flourish, fostering a new generation of scientifically literate and enthusiastic learners who are poised to make meaningful contributions to the world of STEM.



Source: Screenshot from https://schuelerforschungszentren.de/uebersicht-sfz?q&state&subject&targetGroup&view=map on 16th August 2023

2.3 Presentation of best practice 3: MINT-EC Das nationale Excellence-Schulnetzwerk

MINT-EC, the national excellence network of schools focusing on STEM in Germany, stands out as a shining example of exemplary STEM approaches in the country's education landscape. MINT-EC's multifaceted framework is centered on cultivating a profound understanding and appreciation of STEM disciplines among students, fostering a culture of innovation, and empowering the next generation of STEM leaders.

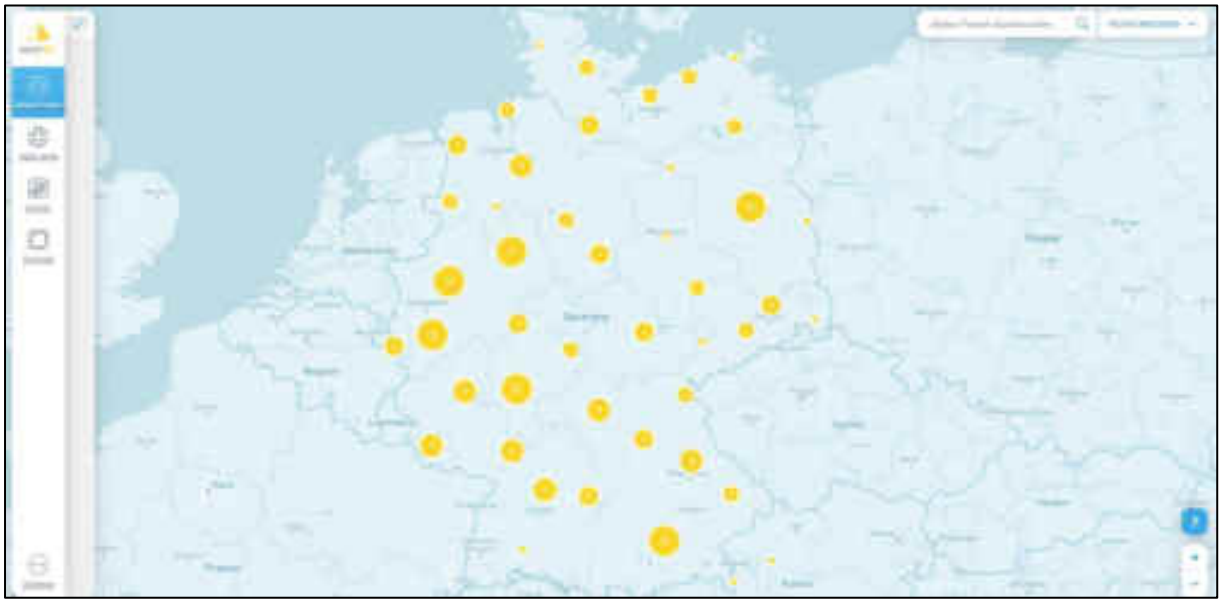
At its core, MINT-EC serves as a promise of collaboration and excellence in STEM education. The network encompasses a select group of upper secondary schools that demonstrate an exceptional commitment to providing high-quality STEM education. These institutions are recognized as "MINT-EC Schools" and are celebrated for their innovative teaching methodologies, advanced curricula, and dedication to nurturing students' passion for STEM fields.

One of the standout features of MINT-EC is its dedication to fostering interdisciplinary learning. MINT-EC Schools encourage students to explore the interconnectedness of STEM disciplines through cross-disciplinary projects, workshops, and initiatives. By transcending traditional subject boundaries, students develop a holistic perspective that mirrors the real-world application of STEM knowledge, an essential trait in today's complex problem-solving landscape.

The network's emphasis on project-based learning sets an exceptional standard for effective STEM education. MINT-EC Schools integrate hands-on projects and real-world challenges into their curricula. This approach not only deepens students' understanding of theoretical concepts but also equips them with practical skills, critical thinking abilities, and collaborative expertise. Such immersive experiences not only make STEM subjects engaging but also foster a lifelong enthusiasm for learning.

Furthermore, MINT-EC's commitment to professional development stands as a testament to its holistic approach. The network provides educators with tailored opportunities for growth, enabling them to continuously enhance their teaching methodologies, incorporate cutting-edge technologies, and stay abreast of evolving pedagogical trends in STEM education.

MINT-EC's influence transcends classroom walls. The network actively fosters partnerships with industry, academia, and research institutions, forging connections that offer students a glimpse into the real-world applications of their studies. These partnerships expose students to mentorship, internships, and opportunities to interact with professionals, cementing the link between education and career prospects.



Source: Screenshot from https://netzwerkkarte.mint-ec.de/ on 16th August 2023

2.4 Presentation of best practice 4: MINT@UniPB

"MINT@UniPB" provides a remarkable demonstration of exemplary STEM practices in Germany, with a particular focus on the University of Paderborn's STEM initiatives. This platform showcases a diverse range of activities and strategies that epitomize effective STEM approaches, emphasizing innovation, hands-on learning, and collaboration to foster a rich educational experience.

At its core, "MINT@UniPB" encapsulates the university's commitment to promoting engagement and excellence in Science, Technology, Engineering, and Mathematics (STEM) disciplines. This initiative vividly portrays the university's dedication to creating a vibrant learning environment that resonates with students' curiosity and enthusiasm. This commitment is highlighted through an excess of activities that exemplify best practices in STEM education.

One of the significant features of "MINT@UniPB" is the multifaceted approach to experiential learning. The initiative showcases various hands-on activities, workshops, and experiments that transcend theoretical boundaries, allowing students to engage directly with scientific concepts. This immersive approach serves as a catalyst for deeper comprehension, nurturing critical thinking skills and a genuine passion for STEM fields.

The University of Paderborn's emphasis on interdisciplinary collaboration stands as a beacon of effective STEM education within the "MINT@UniPB" framework. This initiative encourages students from diverse STEM disciplines to collaborate on projects, reflecting the integrative nature of real-world problem-solving. By fostering collaboration, students develop not only a mastery of their chosen field but also an aptitude for holistic thinking and solution development.

Furthermore, "MINT@UniPB" highlights the significance of research engagement within STEM education. The initiative's commitment to research-oriented learning opportunities, student projects, and partnerships with industry showcases a best-practice model. Such initiatives bridge the gap between academia and practical application, equipping students with the skills and mindset needed to excel in their careers and contribute to scientific advancements.

The emphasis on innovation echoes throughout the "MINT@UniPB" initiative. The platform showcases hackathons, innovation labs, and entrepreneurship programs that challenge students to think creatively and translate their ideas into practical solutions. This approach not only prepares students for the dynamic world of STEM but also nurtures a culture of innovation that fuels progress.

Source: Logo from https://www.uni-paderborn.de/universitaet/mintunipb on 16th August 2023

3 Final comment

The four best practice examples show how diverse and cross-disciplinary STEM approaches can be. Innovative methods have been developed across all levels of education to increase interest and enjoyment in STEM subjects. But special attention is paid to students in schools, as this is where fundamental building blocks for their future careers can be created. And as the examples show, this is certainly possible.

Co-funded by the European Union

Learn STEM

Innovative Model of learning STEM in secondary schools

School Education ERASMUS+
KA220-SCH -
Cooperation partnerships in school education

Overview on existing practices in teaching STEM through innovative pedagogical approaches for Italy

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Date:
17-08-2023

Reference Number:
2022-1-TR01-KA220-SCH-000087583

Content

1 The importance of STEM in Educational contexts

The strategic importance of teaching STEM subjects for a country's social development is well-established, and it is well known how important STEM disciplines are when aimed at as diverse an audience as possible. The future of industry and the economy are based on digital creativity, as well as on the development of new technologies that offer solutions in multiple fields. STEM represents the key topic of a forward-looking education geared toward raising individuals capable of competing, reacting and managing the unknown and uncertain future. To aim for this, it is necessary that students have positive and rewarding experiences from their childhood to their adolescence when passions and interests begin to be defined. The STEM disciplines (Science, Technology, Engineering and Mathematics) are not four autonomous disciplines, but four disciplines integrated into a new educational paradigm based on real and authentic applications. What differentiates the study of STEM from traditional science and mathematics is the different approach and learning methodology. Students are shown how the scientific method can be applied to everyday life. STEM allows students to be taught computational thinking by focusing on real-world applications from a problem-solving perspective. The basis of STEM is research, curiosity, the desire to discover and create new things, the passion for beauty and order, and the use of the rule as a guidance to be able to get to unexplored paths.

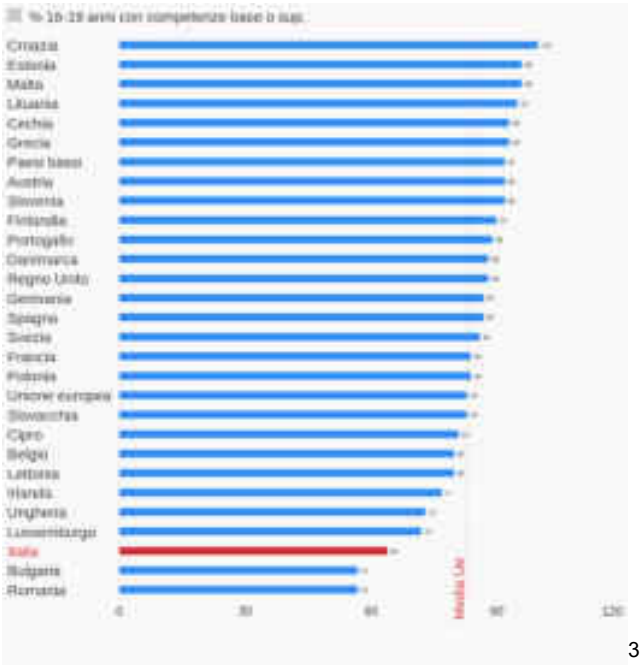
We now live in a world that requires an increasing array of skills and knowledge. Technologies permeate almost every aspect of our lives, from leisure to education, and being in possession of the right cognitive tools to master technologies is nowadays crucial. We tend to believe that only older generations may experience problems with technologies, but, in reality, the problem affects younger generations as well, since what lacks is the awareness of how to properly use modern technologies. For these reasons, STEM disciplines take shape as a tool for citizenship. It is thus crucial to introduce new methodologies of learning in order to provide learners with relevant tools to also live in the reality that surrounds them. Within this framework, it is required a new approach to the STEM disciplines which values the contribution made by scientific subjects in order to be able to read and understand the functioning of the world in which we live. This results in acquiring new fundamental skills, such as the aptitude for logical and computational thinking as well as problem solving. This must be tackled, since in 2022 only 80.2% of young Italians aged 16-24 had basic digital skills in problem solving, whereas the EU average was 93.8%[1]. This has been the second worst data in the European Union, after Bulgaria.

Investing in STEM does not only mean enhancing the importance of the scientific subjects in the traditional sense, but it means making use of a new teaching method which is capable of complementing the classic face-to-face lectures with a laboratory and cooperative approach. In addition to that, it also implies integrating the

[1] Source: https://www.openpolis.it/esercizi/importanza-delle-materie-stem-nel-mondo-di-oggi/

contribution made by the scientific disciplines with other subjects, such as the arts (having the acronym STE**A**M), thus allowing the contamination of viewpoints and approaches to develop a teaching method that enhances the analytic scientific rigor as well as the creativity and curiosity.

However, the humanities in Italy are traditionally and generally considered to be part of the general widespread culture, whereas scientific disciplines are often regarded as a subject reserved for specialists or insiders. Furthermore, in comparison to the international averages, in Italy persists a sharp separation between science and humanities, thus resulting in many implications. The first consequence is a low percentage of young graduates in STEM disciplines in Italy compared to the European average and this results in an impoverishment of the existing human capital in Italy. The second consequence is related to the gender gap: due to social stereotypes, female students are a minority in scientific paths, precisely those that guarantee greater stability and higher salaries in the future. The third consequence is related to the lack of STEM skills, digital skills and knowledge in the youth population. The paradox is that, despite the lack of STEM skills, young generations, more and more connected, do not seem at all excluded from the digital world. However, in addition to that, the lack of training on tools and technologies means that not everyone is able to master these in the same way, thus resulting in inequalities. A study conducted in 2019[2] has shown that Italian youth aged between 16 and 19 are in the last places in the European rankings on mastery of digital skills.



[3]

[2] Source: https://www.openpolis.it/numeri/italia-terzultima-in-ue-per-competenze-digitali-dei-piu-giovani/
[3] Source: https://www.openpolis.it/numeri/italia-terzultima-in-ue-per-competenze-digitali-dei-piu-giovani/

The real risk is that the ongoing digitization processes are not fully inclusive, thus leaving large sectors of society out (mainly those who are socially and economically most vulnerable in the first place and females). For this reason, mass literacy in digital tools and particularly in STEM-related skills is needed from the earliest years of education. Italy, over the following years, will face the digital transition to tackle and reduce the technological gaps in the country. In order to achieve this challenge, STEM skills will be required, both to train specialized professional profiles and also to increase the diffusion of certain basic skills, such as logical and computational thinking, problem-solving or basic knowledge of programming languages or robotics. Italy is working hard to enhance STEM skills, and this has also become one of the main priorities of the National Recovery and Resilience Plan, with the objective of fostering the creation of innovative learning environments for STEM teaching and equipping classrooms and laboratories with new technologies. Hence, these ambitions relate to the strengthening and diffusion of STEM in Italy.

However, nowadays, STEM teaching in Italy lags behind European national averages. The percentage of young graduates in Italy is far more distant from the European average (in 2022 only 29 students out of 100, aged between 25 and 34, have graduated), and the gap of graduates in STEM disciplines is even greater. In Europe, there are on average each year around 21 STEM graduates out of 1000 graduates, whereas in Italy there are 16 STEM graduates out of 1000 graduates[4]. To make matter worse, gender plays a crucial role because women are a small percentage of the total number of STEM graduates: in Europe, there are on average each year 14,9 female STEM graduates out of 1000[5]. As a consequence, the lower presence of women in STEM disciplines results in wage disparities and gender gaps. Furthermore, the low percentage of graduates in STEM disciplines has its root in a lower level of learning these disciplines in comparison to the international averages, starting from elementary school.

What is needed is to foster the passion and interest of young students towards STEM subjects. A low percentage of graduates in these subjects is simply a consequence of the conclusion of a course of study during which students reject scientific subjects because these are perceived as too theoretical, abstracts or far away from the everyday life. In this sense, the STEM approach would bring students from childhood on closer to science through concrete, interactive and cooperative applications, both with other students and also with teachers.

The underrepresentation of female students in STEM pathways often depends on social and family stereotypes starting from the childhood and this has two main consequences. The first consequence is that girls tend to be less confident in their abilities in STEM. The second consequence is that girl with excellent STEM skills underestimate themselves in comparison to men in occupations such as scientist or

[4] Source: https://www.conibambini.org/osservatorio/discipline-stem-ancora-troppi-divari-di-genere-e-tra-nord-e-sud/
[5] Source: https://www.conibambini.org/osservatorio/discipline-stem-ancora-troppi-divari-di-genere-e-tra-nord-e-sud/

engineer. In addition to this, studies[6] have demonstrated that gender gaps in STEM learning are often related to territorial gaps, since the lowest percentage of female learning STEM is concentrated in the South of Italy, which is where learning opportunities are different in comparison to the North of Italy because of more disadvantaged social, cultural and economic backgrounds.

2 Presentation of examples for existing practices in teaching STEM in Italy

The STEM field poses innumerable challenges nowadays, it requires a reskilling and an upskilling for workers, the digitalization of enterprises, the automation of some sectors, and, most importantly it requires new soft and digital skills. As a consequence, new jobs will be created and these will acquire growing relevance, such as the specialists of cloud computing, big data, Internet of Things, artificial intelligence and robotics. STEM disciplines allow the development of skills which are highly demanded by the labour market, but, however, there are still gender inequalities influenced by stereotypes and prejudices, thus making women still a minority in this field. However, school plays a crucial role in guiding learners towards the choice and the study of STEM disciplines, especially in the case of female students. In order to achieve this, it is important to consider best practices in the field of STEM which foster the learning of these disciplines. The best practices related to STEM can be divided into four categories[7]:

1- Initiatives to encourage young students to study STEM disciplines;
2- Upskilling and reskilling initiatives;
3- Initiatives to promote the development of STEM women;
4- Initiatives to foster the employment of female STEM professionals.

The first best practice is *Matabì*, which is an initiative to encourage young students of elementary schools to love STEM disciplines by learning while having fun. Matabì is based on an innovative learning approach and methodology thanks to the use of LEGO® DUPLO® brick sets, which are provided for free to schools, in addition to a special designed training course for teachers and workshops to the classes.

The second best practice is *Code Like a Girl* by Vodafone, which is carried out globally, hence also in Italy. It targets young girls between the ages of 14 and 18 and aims at fostering the development of new competences in female young students in order to equip them with web development, programming and coding knowledge and skills.

The third best practice is *School4Life 2.0*, which is an initiative promoted and supported by 11 Italian enterprises. The project targets middle and high school

[6] Source: https://www.conibambini.org/osservatorio/discipline-stem-ancora-troppi-divari-di-genere-e-tra-nord-e-sud/
[7] Source: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://valored.it/wp-content/uploads/2023/02/Valore-D_ValoreD4STEM_Raccolta-buone-pratiche-2023-1.pdf

students from territories with high dropout rates in order to train and guide them towards the STEM subjects following the "learning by doing" methodology. This initiative can be classified both as an initiative to encourage young students to study STEM disciplines but also as an upskilling and reskilling initiative.

Finally, the fourth initiative is *Nerd? Project* by IBM Italy, which targets female secondary school students in order to spread the passion for computer science and guide their university choices. This initiative groups together all areas of intervention beforementioned, hence it encourages young female students to pursue a STEM career, it promotes the upskilling and reskilling through workshops and training sessions, it promotes STEM women and fosters the future employment of female STEM experts.

2.1 Presentation of best practice 1: Matabì

Matabì is a project which aims to foster math learning through an innovative learning methodology and while having fun. *Matabì* encourages the acquisition of visual-spatial skills through the use of building bricks. The project is addressed to primary classes (3rd and 4th) and involves entire classes. Everyone, girls and boys, can benefit from this new methodology.

Learning mathematics has always been scary for students and results are not always good. So, unfortunately, by age 15, 1 in 2 Italian students do not have basic math skills. The problem with math in school starts early, especially for girls, who are affected more than boys. This gap grows over time: it is small in the early years of elementary school, but, as early as fifth grade, the difference between boys and girls equals about 7 months of learning. The gap then grows again in middle school and becomes equal to 1 year at the end of high school. This results in fewer opportunities for today's girls and tomorrow's women.

Each boy and girl in a classroom will be given a personal kit consisting of 14 LEGO® DUPLO® bricks (inspired by Six Bricks; the kits are given for free to schools) that can be used with the teacher's guidance to solve math problems and to familiarize with concepts related to spatial skills through play. Teachers will be given a training on exercises and activities developed by the Six Bricks in order to use the bricks.

The teacher participating in the project will receive a designed training and teaching materials. The 5 training modules for teachers, lasting 2 hours each, will be about the gender gap in mathematics and how to address it and prevent it; the role of spatial skills and how to improve them; construction play and spatial skills; how to design Matabì workshops; how to build a teaching sheet.

Each class will take part in four workshops to learn more about the project and the innovative methodology. At the end, these practices and experience will be shared in the school with other teachers.

The project has been promoted by Exor, one of Europe's leading diversified holding companies controlled by the Agnelli family. The project has been developed by

Fondazione Agnelli with the scientific contribution of DISMA (Department of Mathematical Science of the Polytechnic University of Turin) and with the support of the LEGO Foundation. The project has become a best practice in the field of STEM in Italy for its innovative learning methodology.

Website: https://matabi.it/

2.2 Presentation of best practice 2: #Codelikeagirl by Vodafone

The global initiative ***Code Like a Girl*** by Vodafone is addressed at young girls and has the objective of stimulating girls' interest in STEM disciplines. The programme has been launched in 2017 and, since then, has reached more than 5000 girls in 26 countries, including Italy, and delivered more than 2.5 million £ worth of free tech education.

The programme, which is the largest international in-person global coding programme of its kind, has been promoted by Vodafone in partnership with Code First: Girls, which is a multi-award winning social enterprise running coding courses for women and girls with the aim of increasing the number of women in STEM.

Code Like a Girl aims to tackle low representation of girls in STEM education, to get more girls into careers that require coding skills, and to help them get a start as STEM entrepreneurs. Programming is becoming one of the most in-demand skills in all industries, and half of all digital job openings come from companies in industries such as finance, manufacturing, and healthcare. In addition to that, female participation is falling in a field that is expanding globally since men dominate the number of STEM graduates in most countries, hence this issue must be addressed in order to close the gap. Hence, empowering women and increasing their skillset through technology are the two main areas of the *Code Like a Girl* initiative. *Code Like a Girl* also has the great ambition of breaking down gender stereotypes by

providing an opportunity for young girls to be trained in technical and digital skills to be used in future academic and professional experiences, thus enriching their background.

The course is designed to be accessible to girls between the ages of 14 and 18, regardless of their skills, but interested in coding. However, preference is given to girls who come from underprivileged backgrounds and who might not ordinarily benefit from this kind of opportunity. The course provides basic and introductory web development skills and knowledge of programming languages such as HTML, CSS, Github and Javascript. Participants, during the 5-day free training, are given tasks to design and develop a website. Each participant is assigned to a team, and, at the end of the course, each team presents the website design to judges and other students.

Vodafone offers participants the opportunity to meet experts of the sector. More specifically, during the course, lectures will be accompanied by conversations with Vodafone experts in the fields of Artificial Intelligence and Digital Marketing to talk about the professions of the future and understand how the digital is increasingly entering the studies.

In order to attract participants, Vodafone has worked on three marketing methodologies: social medias, press releases and school partnerships. Social medias can successfully target and attract young people thanks to the use of hashtag and videos explaining the initiative. Press releases are about stories and testimonials from senior female leaders in Vodafone. Finally, school partnerships are about building relationships with local schools and academic institutions in order to attract more participants and engage more female students in STEM.

Vodafone, in Italy, has a high level of female employment, including in managerial positions. More than 50% of employees are women. This is possible thanks to policies that enhance female talent and a meritocratic culture that helps promote excellence. For these reasons, Vodafone has launched this initiative to train the women of the future.

This initiative has become a best practice in Italy because of Vodafone's engagement and interest in promoting STEM careers by reducing gender gaps and by increasing young female's skillsets through technology.

Website: https://www.vodafone.com/vodafone-foundation/about-vodafone-foundation

2.3 Presentation of best practice 3: School4Life 2.0

School4Life 2.0 is a project funded on the cooperation of ELIS and the Enel Group, with the support of 11 Italian enterprises, among which Poste Italiane, Eni, Illy, Unicredit, Intesa Sanpaolo Bank and Rai.

The project targets middle and high school students, particularly from territories with high dropout rates, and pays special attention to 4th and 5th grade students. *School4Life 2.0* involves young people, teachers, families and business in a joint project which aims to orient, to train, to strengthen the motivation to study, and to pass on useful knowledge in order to be able to make successful choices in planning one's future.

School4Life 2.0 is carried out within the "Sistema Scuola-Impresa" (System School-Enterprise) and fosters direct and constant dialogue between schools, the employment and the territory. The project has been launched in 2022 for two academic years (from March to June 2022 and from October 2023 to June 2023 – the next academic year will start soon). So far, 14.000 students of 133 schools have been involved in the project thanks to the support of 345 role models and mentors during over 3000 training hours and 1109 meetings.

The project has the objective of fostering young people's interest in STEM subjects through school and career guidance, with the underlying idea that enterprises should accompany young people towards a professional future based on the cooperation of schools and businesses.

The project is based on the "learning by doing" methodology through workshops and meetings with experts and technicians of the STEM field in order to make students protagonists of learning and to stimulate motivation and inspiration. In addition to

experts, role models and mentors bring testimonies to young people and educate them in order to raise students' awareness on the SDGs of the United Nations 2030 Agenda. The programme aims to promote the approach of the female student population to STEM subjects and skills, since these are skills that in Italy are still mainly of the male universe, but which will increasingly determine profitable job opportunities.

School4Life 2.0 has become a best practice in Italy for the joint engagement and interest of enterprises in helping students shape their future towards STEM career and in offering help and support to avoid school dropouts.

Website: https://www.elis.org/semestri/sistema-scuola-impresa/school4life/

2.4 Presentation of best practice 4: NERD? (Non È Roba per Donne?) – NERD? (Isn't it stuff for women?)

IBM Italy, thanks to the work of more than 100 female volunteers over the past years, has launched in 2012 the project *NERD? (Isn't it stuff for women?)* with the collaboration of the Informatics Department of the University La Sapienza of Rome and the IBM Italy Foundation.

The project is dedicated to female secondary school students and aims to spread the passion for computer science in order to guide females' university choices. The project aims at showing female students how computer science is a creative, interdisciplinary, social and problem solving-based discipline (an activity in which women excel).

The main goals of the initiative are: overcome gender stereotypes; increase the number of female students enrolling STEM majors; reduce the gender gap in the technological professions; find new paradigms to engage females; demonstrate the highly creative nature of computer science.

Since 2012, over 20.000 young female students of 1250 secondary schools in Italy have taken part in the project. As a result, considerable increases in enrollment of

girls in the STEM faculties in Italian universities have been recorded, from a 15% to peaks of 35%.

The project organizes workshops and training sessions during which girls from the last years of secondary schools learn how to program mobile apps without the need for any prior skills, how to use the IBM Cloud platform, how to work with the Artificial Intelligence, how to build a virtual assistant on one of the topics of the 2030 United Nations Agenda for Sustainable Development. During the program, participants are also given the opportunity to meet and talk with expert women working in STEM in order to be inspired and motivated. Furthermore, participants are also able to work in teams to create a virtual assistant, which will be judged by the IBM team and, at the end of the course, the best creation will receive an award (the winner will be able to take part in an additional 3-days workshop on STEM).

The project is based on the "learning by doing" methodology, which means that fewer theoretical notions on programming are given, but participants are immediately plunged in practice in order to learn how to develop an app and a chatbot.

The value at the heart of the *NERD?* project is to offer women an opportunity to take ownership of their own space and autonomy within a field like IT where women often, even unknowingly, feel very often limited.

In addition to workshops and meeting, the project has also created the "SkillsBuild" platform where learners will be able to find free courses on innovative technologies, artificial intelligence, cloud, quantum computing and blockchain, and, after completion, learners will receive a badge certificate.

The NERD? project has been considered an Italian best practice because of the added value in the STEM field in terms of empowerment and training of young girls in the field of computer science.

Website: https://progettonerd.my.canva.site/

3 Final comment

The field of STEM grouping the disciplines of Science, Technology, Engineering and Mathematics can be considered as a proper pedagogical philosophy. However, instead of teaching independent disciplines, the STEM approach implies the involvement in projects and reality tasks that offer students interdisciplinary learning that resembles the way we work and solve problems in our daily lives. For this reason, the best practices analysed in this research imply a "funny" innovative learning to solve scientific problems and, at the same time, learn new skills and pieces of information. Something interesting about the STEM teaching is how it fosters the curiosity, the cooperation, the critical thinking, the communication and the desire to learn of apprentices. As revealed by the before mentioned best practices, the learning does not occur following the "traditional" methodology, but it implies a learning by doing methodology, which means that little theoretical notions are given at the start of the course, but the way students learn is by practicing and engaging in tasks.

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Learn STEM

Innovative Model of learning STEM in secondary schools

School Education ERASMUS+
KA220-SCH -
Cooperation partnerships in school education

Overview on existing practices in teaching STEM through innovative pedagogical approaches for Türkiye

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Date:
29.08.2023

Reference Number:
2022-1-TR01-KA220-SCH-000087583

Content

1 The importance of STEM in Educational contexts

STEM education has been accepted as an interdisciplinary approach covering the entire educational process from pre-school to higher education. The advocates of STEM education say that students' interest, success and motivation can be increased, especially with real-world problems; they argue that as a result, it will help increase the number of students who make careers in the fields of science in a holistic way (Honey, Pearson, & Schweingruber, 2014). STEM education is an education that supports mental process development, entrepreneurship and product development skills.

TÜBİTAK's (Scientific and Technological Research Council of Turkey) 2011-2016 Science and Technology Development Plan includes some activities that support STEM education of students (Baran, Canbazoğlu-Bilici, & Mesutoğlu, 2015). According to this strategy, it is desired to support science education with science fairs at primary and secondary school level, and activities to be held in the fields of space sciences, mathematics, science and technology for young people.

In order to reveal successful students and teachers in STEM education, TÜBİTAK conducts project studies and organizes competitions. In addition, regarding STEM education in our country, science centers have started to be opened in various provinces by TUBITAK. Science centers aim to eliminate prejudices against science in society by making students love science and scientists. In the science centers established for this purpose, STEM activities are held with students during extracurricular times (STEM Academy, 2013).

Since 2014, the General Directorate of Innovation and Educational Technologies has been included as a national support point in the Scientix Project conducted by the European Schoolnet on STEM education.

The Scientix Project (community project for science education in Europe), managed by the European Schoolnet (EUN) representing the European Commission, started in December 2009 and the Scientix Project website is “http:// http://www.scientix.eu/ ” It was put into use in May 2010. Scientix is a community of 30 European countries that aims to promote the use of technology and good practices in Science education in Europe.

2 Presentation of examples for existing practices in teaching STEM in Türkiye

2.1 Presentation of best practice 1: I MEET ENGINEERING

This project was held in June in 2018 in Kırşehir and supported by TÜBİTAK. The project coordinator was Yusuf Demir Science and Art Center. The students from 12 till 14 years old took part in the project. The aim of the project was to create an

opportunity for successful students in rural areas, to introduce them to engineering education at a young age and to attract their interest and attention to the professions in these fields.

Due to the need for qualified workforce in the fields of Science, Technology, Engineering and Mathematics (STEM), STEM education approach from pre-school to university has come to the fore in recent years. Integration of engineering with the education process increases the demand for professions in these fields.

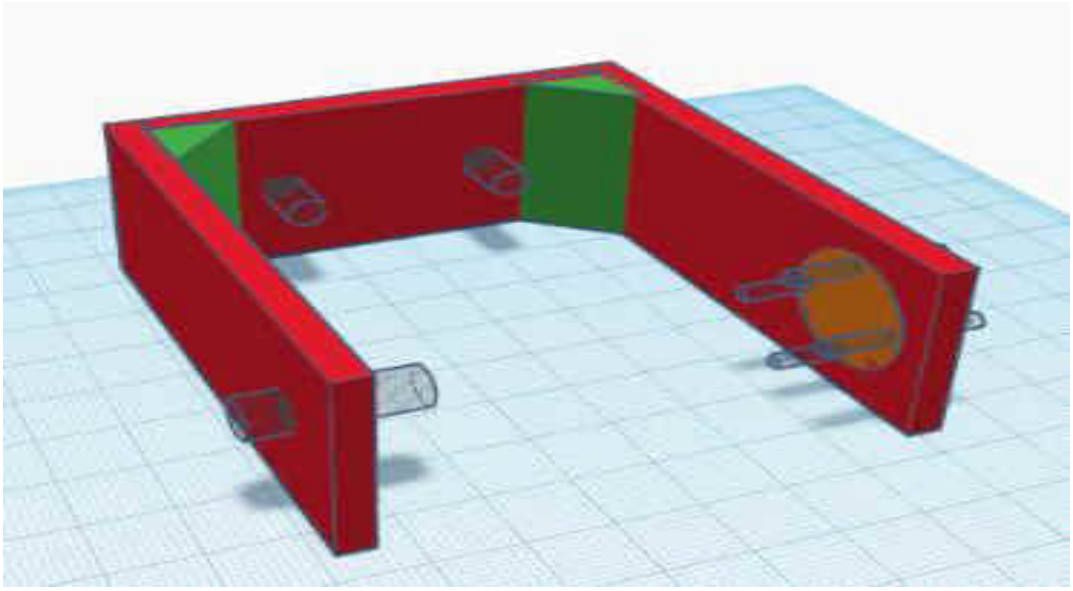
With the activities of the project, students were provided to understand the engineering design process. The students met with agricultural engineering by practicing in the field or garden environment, stepped into computer, software and electrical-electronic engineering with robotic applications, met with chemical engineering by making soap and natural markers, understood the basics of mechanical and civil engineering with STEM activities and had the opportunity to design with a 3D printer.

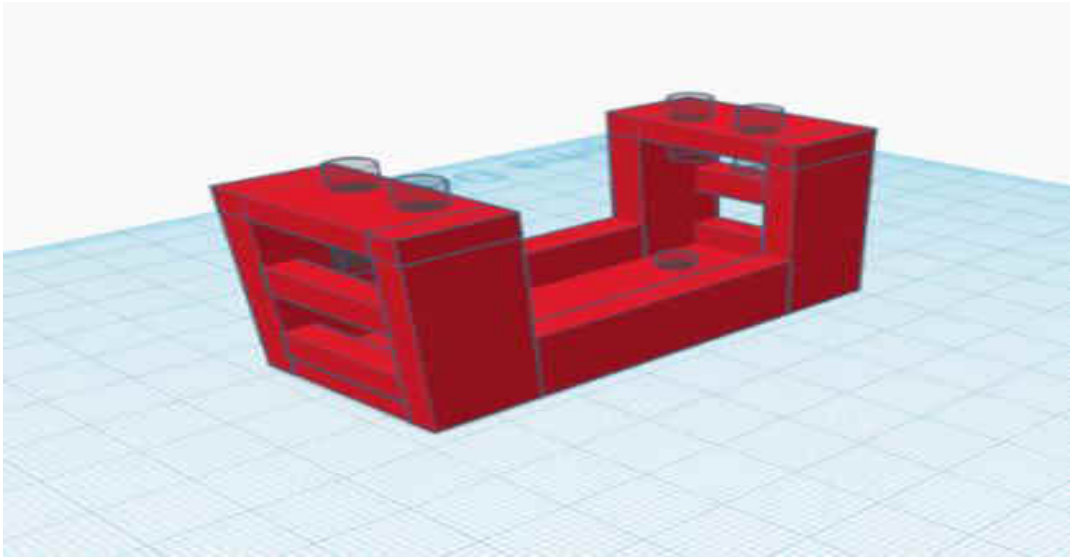
2.2 Presentation of best practice 2: HUMANOID ROBOTIC ARM

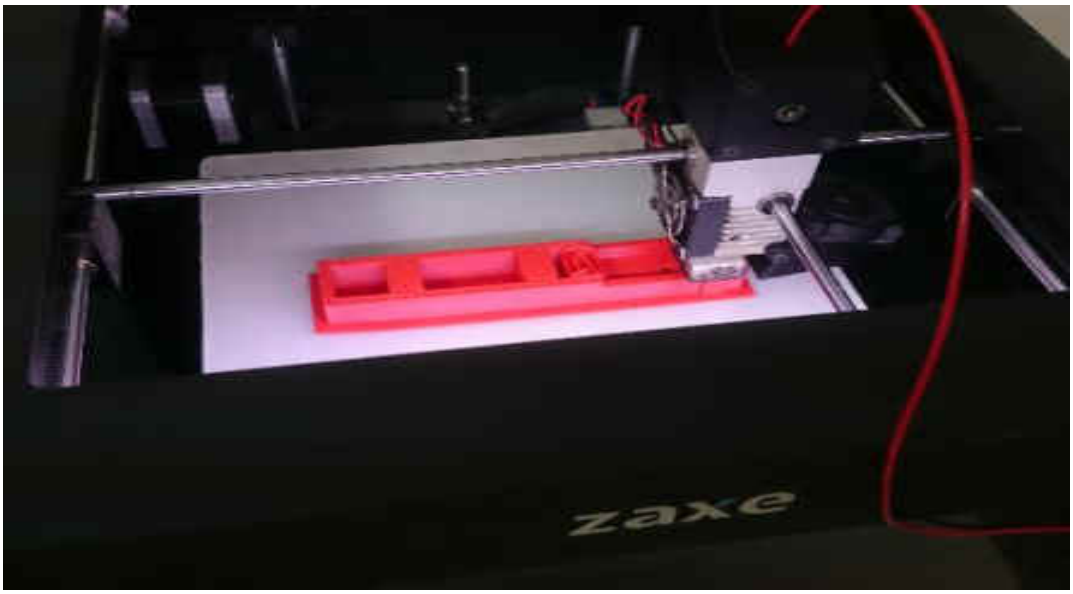
The project was supported by TÜBİTAK and held in March in 2019. The project coordinator was Yusuf Demir SAC and secondary school students took part in the project.

The aim of the project is to design a humanoid robot arm and control this robot arm with the movement of a human.

- In the project, it was examined in which axes and angles a human arm has the ability to move.
- Afterwards, previous robotic arm studies were examined.
- A robotic arm design was drafted, similar to the mobility of a human arm.
- Based on the draft prepared for the robotic arm design, the materials to be used in the project were determined.
- Tinkercad program was used for 3D drawings. The parts drawn in Tinkercad were printed out on the 3D printer.
- Servo motors and connections of the printed parts with each other were made. Finally, the necessary codes were written on the Arduino.
- The robotic arm can do the opening and closing movements of a human with the same arm movement.






zaxe

2.3 Presentation of best practice 3:

PREDICTING TRAFFIC DENSITY WITH MACHINE LEARNING

It is a TUBİTAK project carried out by Yusuf Demir SAC. It was held in March 2022. The aim of the project is to predict the traffic density with the Naive Bayes algorithm, which is a machine learning method.

- In order to determine the factors affecting traffic density and flow, previous studies on this subject were examined.
- In this study, weather conditions, weekday-weekend status, and time of day were used as factors. These factors express the characteristics in the research model.
- The traffic density, which is tried to be predicted as a result of the research, expresses the class variable.
- In the research, Bebek-Arnavutköy Street in Istanbul has been determined as the way of application.

- The data of the study were collected by 3 researchers for about 2 months, paying attention to the fact that there are different times of the day and different weather conditions on weekdays and weekends.
- The researchers then wrote the codes based on the Naive Bayes algorithm.
- With the written program, when the weather, weekdays/weekends and the time interval of the day are entered, the probability percentage of the traffic density and non-busy situation is calculated.
- As a result, it is seen that the program we developed based on the Naive Bayes algorithm has a 78% accuracy rate in predicting traffic density.

2.4 Presentation of best practice 4: YOUNG INTELLIGENCES ON THE PATH TO MATHEMATICS

The project was held in May 2009 and supported by National Agengy Youth for Europe Sub-Action. Gifted students from 13 till 15 years old took part in the project
The main purpose of the project is to ensure the socialization of students and to reach students at schools with low socio-economic level. In this direction, it is aimed for students to socialize, communicate, be tolerant towards society, participate in social activities, strengthen their creativity and entrepreneurship by sharing the mathematical materials they have prepared with their peers.

Co-funded by the European Union

Learn STEM

Innovative Model of learning STEM in secondary schools

ERASMUS+ KA220
Cooperation partnerships in school education

Overview on existing practices in teaching STEM through innovative pedagogical approaches for Türkiye

ALİ ERDEM

KIRŞEHİR AHİ EVRAN ANADOLU LİSESİ

KIRŞEHİR/ TÜRKİYE

Author of the text
Institution, Place, Country

Date:
24.06.2023

Reference Number:
2022-1-TR01-KA220-SCH-000087583

1 The importance of STEM in Educational contexts

To keep up with and sustain digital transformation, Turkey needs a sufficient number of qualified workers. The business world needs a workforce with STEM skills—skills related to science, technology, engineering and mathematics—in order to stay in the race in the global economy, which is led by technology, innovation and digitalisation. An international, generally-accepted STEM education and work classification has not been done, yet there is consensus among experts that some fields require STEM knowledge.In today's world, where technological transformation plays a critical role, productive, entrepreneurial and discovery-based education is fundamental. STEM education not only improves education quality, but it also responds to the needs of the business world as it develops an interdisciplinary approach, teaches how to use theoretical information in practice, encourages critical thinking and instils problem solving skills.

People have started to feel the need to develop themselves with new knowledge in order to adapt to the conditions of the era. One way to achieve this is by informal and formal education that children experience during the first years of life with conscious education models. The task of educators is to fulfill their responsibility in transforming the individual into a creative, critical, productive and dynamic society member in order to prepare the individual for the future world. 21st Century skills enable people to focus on success in education and business. Thinking skills include collaboration, high level of communication, problem solving, information literacy, use of technology, openness to innovation, lifelong learning, decision making, productivity and leadership. STEM, which is one of the interdisciplinary approaches targeting 21st century skills, should be used in formal and informal education experiences from early childhood. With an appropriate learning environment, children will achieve more productive learning from an early age thanks to the STEM areas in which they gain a different life skill in each experience. In practice, the interdisciplinary attitude and the integration of the learned skills will take place. Within the framework of STEM trainings, subjects such as plants, rocks or stones, animals, force and magnets, different substances and their properties, states of matter, seasonal changes, electricity, sound, light, earth and space, living things and living areas can be taken as the lesson subject in primary education. In the program, implementation of many different activities, especially scientific activities are considered.

According to the Constitution of the Republic of Turkey, every citizen has the right to education which is free of charge for the compulsory primary education.Since 2012, twelve years of education is compulsary for boys and girls, which can be divided into 4+4+4 years of schooling.The Ministry of National Education (MEB) runs educational administration of the country and is responsible for drawing up curricula, coordinating the work of official, private and voluntary organizations, designing and building schools, developing educational materials and so on.The central government is

responsible for all educational expenses of the public.The academic calendar generally begins in mid-September and extends through to mid-June, with some variations between urban and rural areas. The school day usually have a morning and an afternoon session, but in overcrowded schools there is a split session.Schools are in session for five days a week (Monday to Friday) in a total of 35-40 hours. The Turkish National Educational System is composed of two main sections: Formal Education and Non-formal Education.

Formal Education : Formal education is the regular education of individuals in a certain age group and given in schools. This includes Pre-Primary education, Primary education, Secondary education and Higher education institutions.

Pre-Primary education: Pre-Primary education is an optional education for children between 3-5 years of age who are under the age of compulsory primary education. The purpose of this education is to ensure physical, mental and sensory development of children and the acquisition of good habits, to prepare children for primary education, to create a common atmosphere of growth for those living in inconvenient circumstances and to ensure that Turkish is spoken correct and well. Pre-school education is given in kindergartens, daycare homes, nursery classes in primary schools, and in private nurseries, all under the supervision of the Ministry. They are usually concentrated in larger towns and cities.

Primary Education: Primary education is compulsory for all boys and girls at the age of 7 and is given free of charge in public schools. These schools provide eight (4+4) years of education. The purpose of the primary education is to ensure that every child acquires the basic knowledge, skills, behaviors, and habits to become a good citizen, is raised in line with the national moral concepts and is prepared for life and for the next education level parallel to his/her interests and skills.

Secondary Education: Secondary education is compulsory for four years and covers general, vocational and technical high schools (Lycees, Lise in Turkish) that provide four years of education (used to be 3 years until 2005).

- General high schools prepare students for higher learning institutions. Some of the secondary schools and the private secondary schools have foreign language preparatory classes. This kind of private lycees have double language education (such as Italian Highschool, German Highschool, Austrian Highschool, French Highschool, and so on).

- Vocational and technical high schools provide specialized instruction with the aim of training qualified personnel.

- Technical lycees include special formations such as electricity, electronics, chemistry, machinery, motors, building, etc.

- Vocational lycees can be Industrial Vocational Lycees; Girls' Vocational Lycees (home economics etc.), Public Health Vocational Lycees, Commercial Vocational Lycees, Agricultural Vocational Lycees, Meteorology Vocational Lycees,

Animal Husbandry Vocational Lycees, Land Registration and Cadastre Vocational Lycees, etc.

The purpose of secondary education is to give students a minimum common culture, to identify individual and social problems, to search for solutions, to raise awareness in order to contribute to the socio-economic and cultural development of the country and to prepare the students for higher education, for profession, for life and for business in line with their interests and skills.In addition to normal high schools, there are also evening high schools usually operating in the same school building. These are designed to allow those who take up employment after primary (or middle school) to continue their formal education.

STEM Applications in Turkish Science High Schools

The idea of establishing Science High Schools in Turkey was discussed in a multilateral project at the beginning of 1963. The Ministry of National Education (MoNE), Ford Foundation, Middle East Technical University (METU), Ankara University, and International Development Agency (AID) participated in this project to establish these schools. In Ankara, Science High School project was a US funded and technically supported project, carried out jointly by the Florida State University, METU, and Ankara University.

Science High Schools' organizational goals were:

(1) to improve students' ability and increase their intelligence in science

(2) to increase the number of qualified personnel in higher education and industry,

and (3) to develop more laboratories by increasing students' scientific knowledge in order to be the center of research and development.

To train teachers in Turkey, a modern building was constructed at METU campus and the education at Ankara Science High School started in 1964. After the success of the Ankara Science High School, the MoNE started the Science High School Projects in Istanbul and Izmir.Today, there are 238 Science High Schools serving as public schools and the same amount of schools serving as private schools.

2 Presentation of examples for existing practices in teaching STEM in Türkiye

2.1 Presentation of best practice 1:

Project Title: Improving STEM Education Across European Schools

https://improving-stem-education.eu/

https://www.facebook.com/ImproveSTEM/

Project Start Date: 25.10.2020

Project Total Duration: 24 Months

Project End Date: 24.10.2022

Partner Organisations:

Applicant Organisation: Academy for International Science and Research UK

1. 21.YY Egitimciler Dernegi Turkey

2. VITALE TECNOLOGIE COMUNICAZIONE - VITECO SRL Italy

3. INSTITUTE OF ENTREPRENEURSHIP DEVELOPMENT Greece

4. Scoala Gimnaziala Gheorghe Magheru Caracal Romania

5. UC LIMBURG Belgium

Aims: GENERAL OBJECTIVE of the STEM project is to develop a methodology for teachers/educators and to develop and implement innovative pedagogies and methods for teaching and assessing STEM in the classroom, making it more attractive in the eyes of young people and students.

Specific Objectives

SO1: Boost a Europe-wide collaboration among STEM teachers as well as education researchers, policymakers and other STEM education professionals, exchanging inquiry-based and other innovative, effective and engaging approaches to science and maths education.

SO2: Transfer of innovative STEM teaching methods to a large number of teachers, an e-Learning Area that will be developed in order to help individuals exploring and sharing innovative tools and techniques to make STEM subjects attractive in the eyes of the students.

SO3: Explore the use of ICT in STEM education, to enhance its introduction in traditional teaching methods and create technology-rich learning environments for students.

SO4: Helping students to develop important transversal skills such as creative thinking, problem solving, etc., that can be utilised by young people in the labour market.

Target Groups: Whereas STUDENTS are targets of all education efforts, TEACHERS are the central agents of the educational ecosystem and their roles has changed from that of primary source of information to someone who creates structure and provide advice for students, monitors their progress, assesses their accomplishments and works as a coach. SCHOOL ADMINISTRATIONS are also within the target group because of their critical role as leaders and decision makers.

Results:

IO1: State of Art / Report on STEM Education & 6 Types of Training Materials

IO2: e-Learning Area/e-Courses (8 Different Topics)

IO3: Mentoring Scheme

“Improving STEM Education Across European Schools” (Erasmus+ KA201)

https://improving-stem-education.eu/teaching-materials/

The overall goal of the project was developing a methodology for teachers to deliver innovative teaching styles to make the STEM evaluation more efficient and its implementation more attractive for students. Over the course of the project we obtained the following results: 10 STEM pedagogical scenarios of which two were created by the teachers in our school. These were also translated in Romanian and listed on the project website (https://improving-stemeducation.eu/teaching-materials/).

I have personally contributed to the one about the active engagement in respecting the habitat. 25 online courses, grouped on nine STEM themes, of which five were created by our school’s coordinator. Again, all courses were translated and can be

found on the project's webpage (https://e-learning.improving-stem-education.eu/) 30 students' mentoring sessions, of which six were hosted by Romanian mentors who answered our call. The sessions were recorded and can be found here https://improving-stemeducation.eu/mentoring-scheme/ Three learning and teaching training mobilities which ten of our school's teachers benefited of. These took place in Greece (Nov 2021), Belgium (Apr 2022) and Ireland (Jun 2022) and had the following main themes: Class Management, Students Motivation, Robotics and Programming, 3D printing and Laser cutting.

I was one of the teachers who took part in the workshop in Belgium The project proved to be complex and challenging, even more given the fact that we were the only institution dealing with younger students. Over the project our school partnered with a university, a Science House Centre, a centre for teachers' professional development, an IT company, and an NGO dedicated to improving teaching.

2.2 Presentation of best practice 2:
Name of the best practice

Erasmus + STEM

INTEGRATED APPROACH TO STEM TEACHER TRAINING

Please, provide here a detailed overview on the second best-practice for your country. Start with a brief overview.

Insert also 1 picture. This should be 2 pages

https://stem-project.org/about

Duration of the project: January 2019 - September 2022

Erasmus + STEM

INTEGRATED APPROACH TO STEM TEACHER TRAINING

This project has been funded with support from the european commission. This website reflects the views only of the author, and the commission cannot be held responsible for any use which may be made of the information contained therein.

The wider project objective is to enhance the quality of STEM Teacher training at partner universities in line with Bologna provisions and needs of knowledge economy.

Specific project objectives:

- To develop STEM Teacher Training Master programs based on an integrated approach;
- To set up STEM regional resource centres providing consulting and engagement services;
- To train STEM ambassadors;
- To train teachers in new skills.

The project is aimed at tackling the partner countries needs in qualified STEM teachers by enhancing quality of STEM education: A unique Master program will be developed in the Teacher training on the basis of integrated approach in consultation with the EU partners. First, the teachers engaged in the new program delivery, then a wider circle of teachers from consortium members and regional universities and schools will be trained in the-state-of-the-art T&A methods.

The achievement of outputs is reached through the implementation of 6 work packages:

1. PREPARATION "Best policies and practices"

2. DEVELOPMENT "STEM Master's program development"

3. DEVELOPMENT "Training framework"

4. QUALITY PLAN "Quality assurance of project implementation"

5. DISSEMINATION & EXPLOITATION "Project visibility and sustainability"

6. MANAGEMENT "Efficient project management and coordination"

During the preparation phase the main project policies and plans will be devised and analysis of key employers' needs conducted. During the development phase main outputs are to be produced. Training of teachers will be done through the cascade model: first, the train the trainer program will be introduced for a small number of qualified teachers; then the trained trainers will transfer the skills to a wider circle of STEM stakeholders. All project outputs will be internally and externally evaluated. The project consortium consists of 10 universities from 4 EU countries and 6 universities from Russia and Kazakhstan. The associated partners will be actively involved in training and disseminating activities.

Duration of the project: January 2019 - September 2022

Erasmus + STEM

This project has been funded with support from the european commission. This website reflects the views only of the author, and the commission cannot be held responsible for any use which may be made of the information contained therein.

2.3 Presentation of best practice 3: The project "Minds ON, Hands ON, STEM Goes ON"

https://www.facebook.com/groups/473363756379571/

https://erasmus-stem.weebly.com/

Description of The Project

• Minds on Hands on STEM Goes on project mainly focused on how science and math education can meet young people's needs and how it can be meaningful and joyful for students. • In the light of the problem, the main aim of the project was to make science and math education more relevant and meaningful for our students in the ways of respect, beliefs and cultural diversity.

• The Project focused on developed key competencies include 'traditional' skills such as communication in one's mother tongue, foreign languages, digital skills, literacy, and basic skills in maths and science, as well as horizontal skills such as learning to learn, social and civic responsibility, initiative and entrepreneurship, cultural awareness, and creativity.

Besides the aims implied above, our project contributed students' and teachers' competences below;

• improving attitudes toward STEM fields and careers

• engaging and supporting girls in STEM fields

• making students excited and enthusiastic about the natural world, learning about ecology and protecting environment

• Improving teacher competences and increasing their awareness on children needs and overcome difficulties in learning science

• broaden the understanding of practises, policies and systems in school education

• increasing opportunities for professional career development

• greater understanding of interconnections between formal and non-formal education

• having a positive impact on our wider school communities

During the Project, we have investigated how students, parents and teachers are engaged and affected by science in everyday life.

We have exchanged our experience and good practices, while organised STEM activities in a formal and informal environment such as camping in nature, visiting museums and aquariums, preparing slowmation (slow animation) about science subjects, organising science fair s and robot festival . A Woman scientist in EU, digital book was created . Led jewellery workshop was implemented .

Teacher Training Course 24-26 October 2017 Antalya/Turkey

• At the beginning of the Project, Teacher Training Course was organised in order to improve teacher competencies and increasing their awareness of children needs and overcome difficulties in learning science.

• The course content encompassed “Integrated STEM Education”, "Nature of Science", "Informal STEM Education", "Learning science in out of school context" , "Slowmation/animation" preparation.

The 24 hours course was held with the participation of the lecturers, two scholars and the contact person of Turkey (PhD student on STEM education). At the end of the teacher training course, twelve teachers and administers were certificated. Certificated teachers informed their colleagues at their schools about STEM education.

STEM ACTIVITY BOOK
https://drive.google.com/file/d/1F5bJFb4r5PoPffgL-FiH4PBusGNUs5OW/view?usp=sharing

PROJECT DAIRY
https://drive.google.com/file/d/1K5wevn0nkEkaX2grUGBD3Qvsh3NO-0t3/view?usp=sharing

DESEMINATION DOCUMENTS
https://drive.google.com/open?id=1ZO1wGDRB4HKmVyaOPhuIFPbmV6cK6du7

STEM Lesson plans
https://drive.google.com/open?id=1zKm3us1oyZhQaSI8uM_DmTkqA--jkv8q

ROBOTIC plans
https://drive.google.com/open?id=1XnGX4CZluVw2xGKPWQ8NAvu9IUtJUrMC

Learning/Teaching/Training Activities - photos during our mobilities
https://drive.google.com/open?id=1D7qrHfYSa2W8HdSymOhU6zE6fxGxF1pr

FACEBOOK PAGE OF PROJECT
https://www.facebook.com/groups/473363756379571/

If a scientist writes a fairy tale – MOVIES
https://drive.google.com/open?id=1OGsA40GhFomwfh8JiA9QtPqrpviitOQR

Women scientist in Europe
https://drive.google.com/open?id=1rkeSl6YSVdUJ1QmXUUvQx67DZFVQUGnf

Led- jewelry pictures
https://drive.google.com/open?id=1Fgn6-_ZjE1uzZ14WUtZfZrilywxRu9oo

Slowmation - slow animation
https://drive.google.com/open?id=1Lkp-oEXhEACTVQPyWDazvYBqq4vSdpqo

Science fair - pictures
https://drive.google.com/open?id=1TjJz1OkoJVodXaUE8Np_htrdn6_KQHLU

LED fashion show
https://drive.google.com/open?id=1lpCWp5dlH0AxEno0rsbrGIpfpKamwlrH

STEM CARER awarness day
https://drive.google.com/open?id=1IYr8TcCfPSBFykTMg-FPjHIUPoOMPnhW

Brochure - leaflet
https://drive.google.com/open?id=1-d0dsQYNCokjw-2MtngMzPDS5JQFQTxg

My country, my region, my school
https://drive.google.com/open?id=1DXce2EvACCOH0U96TgHWbnjQ9WMMcYCI

SCHOOL stem corners
https://drive.google.com/open?id=1PgHd2J6uAbjM5JupS7VLEj_COapomKvD

2.4 Presentation of best practice 4:

https://www.tubitak.gov.tr/en/funds/science-society/national-support-programmes

Supports by TUBITAK.(The Scientific and Technological Research Council Of Turkey). for STEM Education

The projects supported under TUBITAK Science and Society program was for to use STEM approach in the projects.In this project, the main goal is to trigger the participants' curiosity, for research and learning by making them to realize simple scientific facts, not by transferring the knowledge.

TUBITAK 4003 Program of Science and Technology Centers

This program was designed to bring people from different ages and different backgrounds together around science by providing information resources and to trigger their interest in experimental and applied sciences

The purpose of the program is also to increase participants' interest in and attention to science. These centers are expected to increase creativity. Along with their contribution to the science, these centers also have exhibited the history and culture of the regions in which they are located. They present a combination of art and science because the submission of scientific knowledge requires creativity and an artistic perspective. Science centers can help participants to broaden their horizon by using scientific approaches for explanation of daily events. Everyone can demonstrate creative thinking because creative thinking is a skill that can be improved. In particular, visitors can decide on their own whether to contribute to young or adults. Science centers are the center of attraction not only because of their content but also because of the structure within a diversity of green space. Large entrance and waiting room with high ceilings offer a comfortable environment for guests. The entrance with interactive outdoor science center exhibits invites them to the mysterious world of science. TUBITAK aims to develop scientific thinking, to spread the scientific knowledge, to create a culture among the society, to promote asking questions, to raise pioneering individuals, to provide a new vision for society, and to take the leap in science that Turkey has needed by generalizing science centers in Turkey.

TUBITAK 4004 Nature Education and Science High Schools Program

4004 - Education in Nature and Science Camps/Schools Support Programme has been launched in 2007. The program supports training programs, which facilitate the understanding of the target audience on scientific concepts, fields, processes through observation and scientific applications in natural sciences. The activities containing one or more of the following are supported by the program: experimental observations, workshops, field visits, utilization of games or arts for training, drama, measurement and evaluation, focus groups, sports, interactive training. Universities, schools, and public bodies may apply with their training projects for preschool children, primary and secondary school students, graduate and post-graduate students, teachers, governmental personnel.

The aim of this program is to transfer the knowledge to the society in a comprehensive manner while using visualization tools and interactive applications. The main goal in this program is to trigger the participants' curiosity and ambition for the research, query, and learning by making them to realize simple scientific facts.

The aim of this program is:

• To popularize the science and scientists,

• To emphasize the entertaining part of science,

• To overcome prejudices, negative concerns about science and scientists in society and student concerns,

• To build bridges between the school and research organizations

• To develop scientific process skills,

• To provide an understanding of the nature of science,

• To understand the interaction among science technology, society, and individuals,

TUBITAK 4005 Science and Society Innovative Activities and Practices Program

4005 - Innovative Educational Applications Support Programme was launched in 2013 and designed for graduate students, academicians in universities, permanent teachers working actively in an institution, and employees of science centers run by public and municipal affiliates. Innovative Educational Applications Support Programme covers interactive activities that provide the students with the necessary knowledge and skills through innovative approaches to arouse interest and curiosity in their branches, develop positive attitudes, increase their motivation and enable them to learn. Since 2018, the project coordinator should have a Ph.D. degree.

This program was related to the topics about teachers' training. The program aims to arouse teachers' interest, to teach the content knowledge and improve skills to increase their motivation, to develop positive attitudes, to gain innovative approaches through interactive methods and techniques in science related subjects, and to raise the awareness of teachers in innovative approaches outside the traditional teaching methods,Some examples to achieve the objectives under this program are presented in the following paragraphs. Quantum Physics and Optics Laboratory offer exciting opportunities for computerized monitoring of research and applied physics. Students in applied research frequently learn theoretically and experimentally with new devices

in optical, electromagnetic, acoustic, nanotechnology, photonics and systems. In optical projects, imaging systems, vision sensors, color, human perception, image processing, holography, laser interferometry and other applications are located. Students in Modern Physics Laboratory were engaged in research on metamaterials, holographic data storage, atoms, quantum, nuclear, solid state, and elementary particle physics. The main target of the laboratory followed by professionals in the field of contemporary research topics is to attract the attention of students in cooperation with schools. Optics and some projects are carried out in the Modern Physics Laboratory:

TUBITAK 4006 Science Fair Support Program

In accordance with the protocol signed between the MoNE and TUBITAK, the program was established to develop the scientific culture of our country (The Scientific and Technological Research Council Of Turkey, 2015). Within the framework of the school curriculum, students have been studying courses and making research on the issues that they have identified by their own interests, so that they can share the results of their research. Therefore, the program needs to include following items to create an environment where the learning is fun for all:

• Encourage the adoption of science and scientific work by the new generations,

• To link the science to everyday life,

• To develop research techniques and scientific reporting as well as to distribute the scientific presentations in order to improve young people's skills,

• To provide an opportunity for every child in different science projects and cognitive developmental level,

• To create new environments and opportunities for students to do research projects and sharing,

• To introduce entertaining and interesting part of the science to students to eliminate the pressure of competition on students,

• To ensure equal access for scientific projects to school districts in different socioeconomic levels,

• To teach how to adapt the science and solutions to real-life problems.

4007 – Science Festivals Support Programme has been launched in 2015. This program aims to create awareness on basic scientific concepts and to promote the curiosity, research, questioning, and learning behavior in public, by science communication, exploitation of scientific knowledge to a large community, understanding of the interaction between science and technology via exhibitions, shows, performances, laboratory applications, science games, contests, and interviews. Universities, science centers of public or local administrations, municipalities, and other public bodies may apply for getting support in the organization of science festivals in their premises, region, or city.

The aim of this program was to provide science communication, to spread scientific knowledge to a broader community, to raise the interaction of science and technology for public, and to comprehend exhibitions, stage shows, performances, workshops/laboratory work, thematic science games, contests, interviews and so on (The Scientific and Technological Research Council Of Turkey, 2015).

TUBITAK 5000 Open Source Digital Content Support Program

The overall objective of the program is to accelerate the creation of high quality e-books and e-courses for K-12, so that equal opportunities for all students can be provided (The Scientific and Technological Research Council Of Turkey, 2015).

4008 - Inclusive Science and Social Practices Support Programme for Individuals with Special Needs

The programme was first launched and the call was published on April 23, 2022. The programme aims to raise awareness among individuals with special needs and those who provide services to them through the projects that are supported by the programme. It aims to facilitate their integration with society by providing support in education and independent living and to ensure the spread of scientific practices for these individuals.

3 Scientific Meetings Grant Programmes

SUMMER SCHOOL AND RELATED ACTIVITIES SUPPORT PROGRAMME FOR MSc AND PhD STUDENTS

Purpose:
Within the context of the program, summer schools are supported in accordance that they aim to transfer the current improvements in the Science and Technology and to teach the currently used techniques in the fields of Natural Sciences, Medical Sciences, Engineering and Technological Sciences and Social Sciences and Humanities.

NATIONAL SCIENTIFIC MEETINGS GRANT PROGRAMME

Purpose:
to support the scientists pursuing post graduate education/research and post-doctoral research programs in the fields of Natural Sciences, Medical Sciences, Engineering and Technological Sciences and Social Sciences and Humanities due to their participation in national, international or with international participation scientific events.

“TRAINING THE TRAINERS” PROGRAMME

Purpose:
to support the primary-secondary school and undergraduate students who show excellent achievement and encourage them in their academic and scientific performance by supporting science camps, theoretical or applied summer or winter courses. Additionally, the programme includes seminars for high school teachers and academicians.

4 Final comment

Teacher training about STEM education in Turkey

Innovation is very important for countries. It is an interactive and multidisciplinary process and tightly connected to life. In our time, there is a clear consensus among stakeholders on the importance of STEM education to the innovation.

Well, what is STEM education? STEM is an abbreviation of the “Science, Technology, Engineering and Mathematics” words. It is a curriculum based on in an interdisciplinary and applied approach. STEM integrates these four disciplines into a cohesive learning paradigm based on real-world applications.

The objectives stated by Turkey’s Vision 2023 and the Ministry of National Education (MoNE) strategic documents require defining STEM education on a national scale In June 2017, regulations in national education policies announced that STEM education would be applied for the first time in secondary school level in Turkey. This education would be gradually expanded to all grade levels starting from the 5th grade and be covered in the last unit in all grade levels. With the curriculum revised at the beginning of the 2018-2019 academic year, schools started offer STEM education

under the name “Science, Engineering and Entrepreneurship Practices” starting from 4th grade.

This revised curriculum states that science, engineering and entrepreneurship practices will be embedded in all units within an academic term and students are expected to realize the design and production process of products in connection with the related units in the school environment (MoNE, 2018). The age of innovation, which we are already in, guides a generation to lead the country in the future. Called as “Generation Z” or “digital natives/digital settlers”, these children interact and socialize with mobile communication tools. Unlike the generations preceding them, these digital natives are exposed to information and communication technologies since the moment they are born. Providing this generation, which constitutes 17% of Turkey’s overall population, with a well-planned STEM education will make it possible to create a sustainable economy and having a greater say in global competition. While a new generation is expected to lead the changing world, it is unthinkable that education is not affected by this change. In this respect, STEM education to be delivered through distance education could allow teaching to emerge from the boundaries of traditional schools, to ensure equal opportunities in education and to provide students with the skills of the modern age. However, while research on distance education has been increasing recently, studies on distance STEM education have been limited. In addition, how to ensure the sustainability and feasibility of STEM education is a problem to be discussed.

Therefore, distance STEM education can be considered as an alternative education approach that can provide solutions to these problems. As a matter of fact, it should be taken into consideration that this education is an inevitable need for career development of students, teachers and administrators and for the future of countries. Within Turkey context in particular, the status of current STEM education practices and the feasibility of STEM education could be considered as issues that should be investigated in detail. In order to apply STEM education in Turkey, the existing curriculum, infrastructure and teachers’ competence for this education should be identified and supported within the framework of an innovative educational policy.

Conclusion In Turkey, public and private science high schools contribute to the actualization of 2023 targets by submitting qualified students to universities.

For a better quality, the following suggestions should be considered.

1.Curriculum needs to be changed to accelerate the transition from industrial society to the information society, so individuals should be trained for future technologies and professions. Laboratories in STEM High Schools should be updated.

2. Physical conditions of high schools should be improved to the best level. Cooperation between alumni, students, parents, and schools should be strengthened.

3.There should be cooperation between universities and schools for K-12 such as METU and Ankara Science High School. Freedom in decision-making and implementation should be provided to the science high schools.

4.Science high school teacher selection should be rearranged according to much more objective principles (McKinsey & McKinsey, 2007).

5. Master of philosophy and doctorate in teacher appointments and knowledge of foreign languages should be set as prerequisites.

6. In-service training for teachers should be permanent, teachers' knowledge and experience should be enhanced, and teachers should go to abroad, so that they can be up to date about new developments in the world.

7.More resources and new programs must be devoted to public and private science high schools.

Journal of Education in Science, Environment and Health (JESEH) 187

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