INNOVATIVE SCHOOLS: TEACHING & LEARNING IN DIGITAL STEM LABS
2020-1-TR01-KA226-SCH-097611

COMPARATIVE STUDY
INTELLECTUAL OUTPUT 1

THE STATE-OF-THE-ART SITUATION IN STEM EDUCATION CONCERNING THE DIGITAL READINESS

OUTPUT TYPE: STUDY/ ANALYSIS-RESEARCH STUDY/ REPORT

PROJECT
"INNOVATIVE SCHOOLS: TEACHING & LEARNING IN DIGITAL STEM LABS"
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Comparative study

The State-of-the-art situation in STEM education concerning the digital readiness

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Contents

1. Project Innovative Schools: Teaching & Learning in DIGITAL STEM LABS

In our digital era, the traditional concept of schooling, based on a re-production model (knowledge acquisition) where there is one classroom, one teacher, one class, and one subject at a time, is being increasingly questioned. Technology co-evolves rapidly with new learning practices. Learning becomes increasingly blended or hybrid which means that Face-To-Face and Peer-To- Peer instruction is often combined with virtual learning environments. Rethinking the relationship between education and practices that scaffold knowledge creationis vital. Technology has produced fundamental changes in the educational world. Different technologies may promise different forms of contribution to education. Technologies improve teaching and learning in Europe: with Open Educational Resources (OERs), digital devices and computing, and computer data systems.

Based on the relevant momentum created in our digital era, the project "Innovative Schools: Teaching & Learning in DIGITAL STEM LABS" will design an innovative framework curriculum and corresponding teaching/learning method "DIGITAL STEM LABS" for delivering digital contents related to science, technology, engineering, and mathematics (STEM) educational skills that will be based on cross-sectoral cooperation and interdisciplinary approaches.

The contemporary STEM skills related to natural sciences are, to a large extent, neglected by the secondary school curriculum in countries represented by the project partners of this project. In the context of the cross-curricular/interdisciplinary approaches as well as relevant pedagogical approaches, currently, there are no targeted pre-service education and inservice (continuous) training opportunities for secondary school teachers of general subjects in Turkey, Greece, Lithuania and Spain that systematically cover the innovative pedagogies in STEM contents and related concepts (e.g. curriculum integration, innovations in educational settings, smart specialisation, participatory approaches etc.) in the context of the cross curricular/ interdisciplinary approaches as well as relevant pedagogical/didactical approaches.

Given the fact that the project "Innovative Schools: Teaching & Learning in DIGITAL STEM LABS" will include relevant training and exchange/mobility activities for relevant secondary schools teachers as well as the fact that those teachers will be directly involved in the development of innovative, digital Intellectual Outputs of the project in cross-sectoral cooperation with experts/professionals form relevant organisations, the project will strengthen the profile of the teaching professions and the prestige/leadership roles of involved teachers in their local communities/professional environment by means of:

- enhancing the competencies of teachers in secondary schools/gymnasia for developing crosscurricula/ cross disciplinary contents in relation to distance education regarding STEM skills and related concepts (social innovations, smart specialisation, participatory approaches)
- ensuring exchange of good-practices among the secondary schools-project partners regarding the teaching standards, innovative pedagogies and didactic materials used in crosscurricular investigation of digital education.

In parallel to the above described developmental issues, project "Innovative Schools: Teaching & Learning in DIGITAL STEM LABS" will disseminate innovative experiences in the field of STEM education and integrate them into the new Curriculum Framework "DIGITAL STEM LABS". The project will consider the following definition of the social innovations: "Social innovation are new ideas or processes (products, services and models) that meet various social needs and contribute as well to the creation of new relationships and/or collaborations. In other words, these are good innovations for society and at the same time they improve its capacity to act".

The world is changing around us. Digital technology has become a core part of our everyday lives. Advances in technology impact everything, especially the world of work. Entire job sectors are emerging or disappearing, and workforces are rushing to keep up with change. Automation and globalisation are changing the way we think about, and define, careers. Employment is becoming fluid, and people will go from having one profession to several in their working life. As

the world of work changes, we will need to change our skills to match. The gap between the knowledge generated in the education system and the skills demanded by employers and individuals is widening. Overcoming these limitations requires a priority focus on science, technology, engineering and mathematics (STEM), including the development of workplace skills in STEM. Future careers will also rely heavily on '21st century skills'— for example, critical thinking, creativity, cultural awareness, collaboration and problem-solving. When done well, STEM education complements the development of 21st century skills. It's predicted that future workers will spend more than twice as much time on job tasks requiring science, maths and critical thinking than today.

STEM learning is also important for students in their everyday life in our contemporary world, with the rise of new technologies in biomedicine, microfabrication, robotics and artificial intelligence. The ability to understand and apply data, and develop solutions to complex problems, will be important life skills. While STEM skills are crucial for changing future, according to research conducted by the International Student Assessment Program (PISA, 2018), Turkey, Spain, Greece and Lithuania are in the area of natural science literacy well below the OECD average. That is because of the fact that students do not have the motivation to further their study in STEM subjects. They are prejudiced by the STEM area and do not notice the connection with everyday situations as well as other subject curricula.

Students, teachers must develop a growth mindset. Therefore, it is necessary to turn to innovative forms of teaching. The educational system must undergo significant changes to meet the changing situations.

The COVID-19 pandemic has not only limited the way people can relate to each other and perform their most basic everyday-tasks, but has also had a significant impact on the regular delivery of education. There is a digital transformation of education and training systems. The

crisis has resulted in a significant increase in online teaching. Much of the training that is conducted as face-to-face in classroom environments has been pursued online.

As such, the crisis provides a powerful test of the potential of teaching and learning online. It also highlights its key limitations, including the prerequisite of adequate digital skills, inadequacy of course materials appropriate for distance learning, the difficulty of delivering experimental materials of STEM learning online, and the struggle of teachers used to classroom instruction.

Against this brief background, secondary schools should develop new STEM methodologies prominently and permanently on their cross-curricula agendas. This is to say, the appreciation of an innovative and digital STEM curriculum appropriate for distance learning should be considered as highly relevant for secondary level students with a view of:

• reinforcing the ability of education and training institutions to provide high quality, inclusive digital STEM education;

• building capacity to implement STEM education online, blended and distance teaching and learning;

• developing digital pedagogical competencies of STEM educators, enabling them to deliver high quality inclusive digital education;

• developing and/or using high quality digital content such as innovative online resources and tools in STEM education.

The partnership of secondary schools and higher education institutions will promote networking of institutions across the EU, sharing of resources and expertise, and collaboration with digital technology providers and experts in educational technologies and relevant pedagogical practice, to develop tailor made solutions adapted to local challenges and realities in STEM education.

1.1. Partner Organisations

Project Coordinator

Nezihe Derya Baltalı Bilim ve Sanat Merkezi is located in Pamukkale, Denizli, Türkiye. It was founded in 2001, as one of the peer science and art centers in Turkey. It is a governmental institution that provides supplementary education to the gifted. Our students are aged between 8-18. We have 701 students both in arts and general intellectual ability. We carry out a project-based education and curriculum special to these pupils individually or in small groups of max 8. Following contemporary trends and changes in education, all our teachers continuously work on their professional and personal development, visiting and organizing numerous seminars, trainings, presentations, participating in the preparation of various projects and competitions in the country, with the aim of providing high quality and more creative services to those for whom this institution exists, and these are our students.

For the same reason, the school is equipped with modern teaching and support tools, both in IT lab and in cabinets for: mathematics, biology, geography, chemistry, physics, informatics and robotics. There is a multimedia classroom, a festive hall, a media library, and the modernization of the other classrooms follows. We have interactive boards in all classrooms. We strive to enrich life in school with various creative and imaginative contents of educational, cultural, humanitarian and entertainment character. We do this through the realization of numerous sections, extra-curricular activities, national and international projects, participation in eTwinning projects that got National and European Quality Labels etc. The school was awarded eTwinning School Label in 2019-2020 Academic Year.

Nezihe Derya Baltali Bilim ve Sanat Merkezi is highly regarded for:

- A broad curriculum including career advice;
- The use of ICT tools to enhance the engagement of, and successful outcomes for students;
- Science, Technology, Engineering and Mathematics (STEM), Literacy and Numeracy;

• STEM project-based learning activities that can be tailored to meet your students' needs.

STEM at Nezihe Derya Baltali Bilim ve Sanat Merkezi is committed to:

• Developing an engaging curriculum for STEM subjects;

• Providing teachers with relevant skills and resources to support student learning;

• Giving students opportunities to participate in activities, events and other initiatives;

• Increasing retention in STEM subjects;

• Developing pathways to post school employment and Careers in STEM industries.

Partner organisations

Pamukkale University is a state university which was founded in 1992 in Denizli. Today with its 16 faculties, 6 institutes, 3 higher education schools and 15 vocational higher education schools, Pamukkale University is training, modern, knowledgeable, creative and enterprising young brains, who Turkey and the world need, in various fields such as medicine, engineering, economic sciences, science, social sciences, fine arts, educational sciences and technical education. Despite its short history, with its 60 000 students and 5 000 employees 1500 of whom are dynamic, open-minded and challenging academics; Pamukkale University has formed a modern education & instruction and service atmosphere. The university gives great importance to international studentinstructor exchange and international partnerships and has signed hundreds bilateral agreements with universities all around the world and more than sixty general cooperation agreements with Europe's and world's leading universities. Pamukkale University has completed successfully more than thirty Socrates and LLP programme projects (including Leonardo Da Vinci projects) and four Youth projects. Some projects from LLP program are still ongoing as well as new KA1 and KA2 projects from Erasmus+.

The Faculty of Education at Pamukkale hosts on of the leading centres for Science Teacher education in Turkey. The theoretical as well as applied courses that the Faculty offers enable prospective teachers to become professionals who are constantly in touch with recent scientific and technological developments and who have the willingness and capacity to apply these developments to their own teaching activities. The Faculty of Education also cooperates with the Graduate School of Social Sciences and the Graduate School of Natural and Applied Sciences to offer graduate programs which train students as prospective researchers and academics. In addition, the Faculty of Education is engaged in various research and consultation activities in relation to education, and for this purpose it cooperates with the Ministry of Education and with some private educational institutions.

Faculty of Engineering at Pamukkale University provides a modern academic environment supported by the state of the art facilities and highly skilled academic staff. Various national and international research projects conducted by academic staff provide significant contributions to the world of science and technology, and in addition, the results of these projects are being applied at local organizations, schools, and industries. Faculty of Engineering building has various laboratories equipped with high-tech experimental sets and rigs designed to provide an effective learning environment to its undergraduate students as well as laboratories for graduate students for their experimental research toward their masters and/or doctoral work.

PANEPISTIMIO KRITIS (University of Crete) is a multi-disciplinary, research-oriented public educational institution. Located at campuses in Heraklion and Rethymnon on the island of Crete, a site rich in ancient and modern Mediterranean cultures, the University offers a vibrant social and intellectual environment for research and education.

Established in 1973, the University accepted its first students in 1977-78. It now has 16 Departments in 5 Schools (Philosophy, Education, Social Sciences, Sciences & Engineering, and

Medicine) as well as a number of affiliated institutions, including the Skinakas Observatory, the Natural History Museum, and the University General Hospital. Currently, over 16,000 undergraduates and 2500 postgraduate students are registered here. They are educated by an outward looking academic faculty of around 500 members, supported by adjunct lecturers, post-doctoral researchers, and laboratory instructors as well as around 300 technical and administrative staff.

The international orientation of the University is reflected in its track record of collaborations with many of the leading research and educational institutions in Europe and worldwide as well as active promotion of mobility and exchange programmes. Research and research training at all levels benefits also from the close collaboration between many of the University's research groups with the Institutes of the Foundation for Research and Technology – Hellas (FORTH) and the Institute of Marine Biology & Genetics (IMBG) Research and research training activities at the University are organized along the lines of the Divisions within each Department. Research activity follows the classic academic model insofar as it is driven by the initiatives of scholars and scientists in developing their own curiosity-driven or practice-based projects or working in collaboration with other research groups. These collaborations mirror the increasingly multi-disciplinary and inter-disciplinary character of both basic and applied research, which is also reflected in the interdisciplinary character of many of the University's postgraduate studies programmes.

Consistent with its research orientation, the University of Crete is the first Greek University to have signed the EU Charter and the Code for the recruitment of researchers, and forms part of the EURAXESS European network for the mobility of researchers. The University fully participates in quality assurance mechanisms and is committed to meeting quality standards both for its academic and administrative structures.

The University is committed to providing a stimulating environment that promotes education by teaching and research. We strive for excellence in teaching, research and community partnerships and aim to

• provide a secure and open teaching and learning environment for our students,

• take a leading role in research and the resulting innovations,

• promote the cultural, social and economic development of the region and

• develop and strengthen collaborations with other academic institutions within Greece, Europe and worldwide

The Science Education lab is established, in 1989, at the Department of Primary Education at the University of Crete, Greece. The head of the lab is Prof. Stavrou D. since 2015. The Science Education lab focuses on research about the educational use of digital technologies and the integration of the educational innovations of ICT such as dataloggers, virtual & augmented reality and educational robotics in STEM teaching. Particularly, master degree theses as well as bachelor theses are revolved around developing teaching materials for science lessons with the use of microcomputers, robotics and virtual reality environments. Moreover, the Science education lab give emphasis on pre-service & in-service teacher education and also studies the influence of informal and out-of-school contexts in STEM education.

Considering its educational role, the lab offers training to pre-service primary teachers both in content knowledge and teaching methodology knowledge in the domains of science, mathematics and technology. Main educational goals of the Science Education lab are a.) the integration of the educational innovations of ICT in science teaching at the primary school b.) cultivating inquiry and engineering skills in pre-service primary teachers, through the construction of interactive artifacts which relate to real-world STEM projects and concurrently address contemporary socioscientific issues, c.) the integration of mathematics in science lessons concerning contemporary topics.

3rd Junior High School of Rethymno is located in Greece. The school has about 350 students (12- 15 years old) and employs about 40 teachers. Also there are 7 people, support staff (restaurant, security guard, cleaner) all paid by the state. It is a public school of general education, which after three years in Liceum can lead their students to University. Students take courses in: Literature, Philosophy, History, Sociology, Mathematics, Physics, Chemistry, Biology, Geography, Arts, Technology, Sports, English, French and German. Our school is very much aware on issues about the environment, sustainability and climate change, so it has participated in many projects, both National and European. The schools also participates in virtual visits-presentations with CERN and ESA.

Our school of course offers asynchronous (Edmondo,Google-Classroom ,e-class) and synchronous (zoom,webex) education to its students, especially in extreme situations (covid-19, weather) The school has participated in several European programs on alternative sources of energy, space living, robotics and theater. Also it has been developing eTwinning programs for the last three years. We have got National Quality Labels for all of them. Indeed, last year it received the European Quality Label for the project '' Travelling to different biomes''.

Universidad Rey Juan Carlos is the youngest and most modern of all public universities in Madrid. It has four campuses, located in Móstoles, Alcorcón, Fuenlabrada and Vicálvaro (Madrid), as well as its Foundation in the city center. It was created in 1996 with the objective of offering all-round preparation for its students, combining theoretical teaching with training in laboratories and companies, thus facilitating rapid access to the labour market. The university has, at present (course 2016/18), more than 38.000 students enrolled, including 5.200 international students from over a hundred countries from all over the World, and a staff of more than 1.900 members, including both teachers and administrative personnel.

Regarding Social Sciences, Rey Juan Carlos University (URJC) develops intense research activities in the Social Science field, both national and international. From the URJC has strengthened the relationship between different groups for the development of projects and the fundamental role of Social Science to tackle them.

Thus, by facing projects as a challenge to be solved from different perspectives (technological, social, economic …) URJC has achieved to increase the number of proposal approved and funded, being significant the growth in the number of projects in which URJC has participated (and coordinated). URJC enforce it from specific projects in Social Sciences, as another projects from different topics, but where a Social Sciences approach is necessary to accomplish them.

Social Sciences have played an important role in the overall activity of URJC. Thus, it is noteworthy URJC commitment in this point and experience, as demonstrated by participation in both competitive national and international research programs. Among the several projects in the area of Social Sciences in which URJC has participated include, inter alia, studies on poverty and public policy, corruption and money laundering, disinterestedness of citizenship by politics in Europe funded by the Spanish National Research Programme. Other projects regarding Social Sciences are: Intelligence and democratic systems, environmental safety and energy vulnerability, gender studies, eDemocracy, and several projects funded by private institutions.

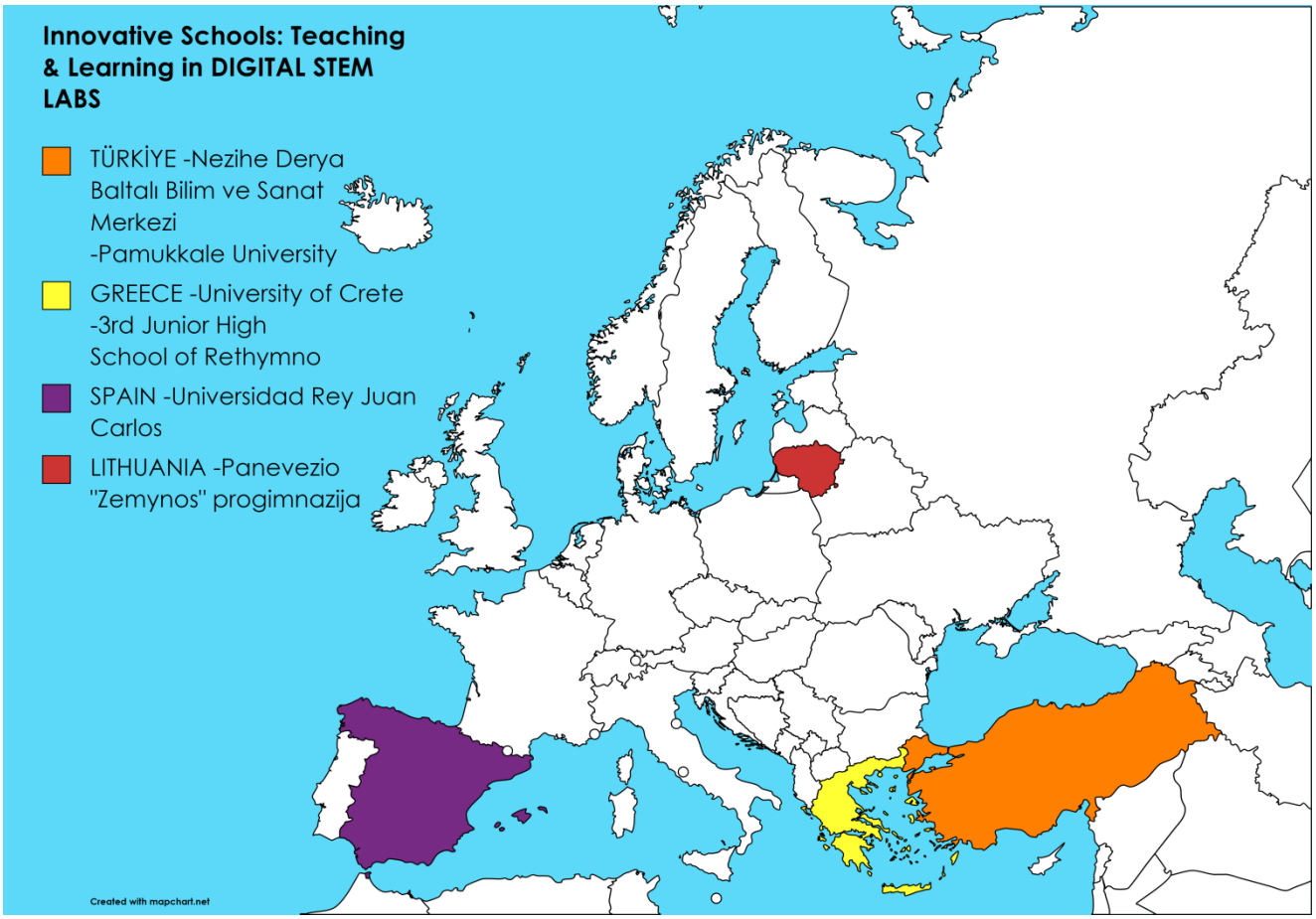
Furthermore, URJC has actively participated in international projects and programs that deal with "Science for peace and security". It is interesting to stand out projects funded by 7FP regarding terrorism such as "How Terrorism Ends: A Comparative Analysis of Underground" (Marie Curie Programme); or "Study on the methods through which violent radicals mobilize support for terrorism and find new recruits" and "The victimization experience and the radicalization process: an understanding of the perpetrator victim cycle amongst individuals involved in terrorism". In the same way, it draws attention projects focus on "Organized Crime Portfolio" and "Tackling Illegal Economy", funded by the Security and Safeguarding Liberties1

(ISEC Programme)". Finally it is also remarkable URJC participation in the Minerva Research initiative" funded by USA Department of Defense.

In short, URJC has been active and with good returns both in projects and funding in Social Sciences.

Panevezio "Zemynos" progimnazija is located in Panevėžys, in the north of the country. Our school is attended by 629 students from primary and progymnasium aged 6-15 years. One of the most important missions of the school is to develop the mind of the student in all areas to become a fully responsible adult. It was proposed to provide educational services and qualitybased training, performance, promotion of European values, equality of opportunity for all and open to learning and training at throughout life. We want every student in our school shape and continuously improves its core competencies to continue his studies and for life. Our school is open to students with special needs, in increasing numbers each year. We have 40 classrooms, a computer lab, a library, a director's office and. We also have a swimming pool, where participants of Olympics games are trained and a new football pitch. Our school has 2 digital classrooms equipped with laptop, tablets, smart board and speakers and have robotic classes. We have also an ICT classroom. Students have the opportunity of attending many courses and clubs according to their interest. In addition to it, our students can take courses in any subject they want ranging from English to Science . We also organize festivals every year (Dancing festival) and swimming competitions every month. Families appreciate our effort which makes us happy. Whereby we set up the communication bridge with parents. Our teachers work for the full development of human personality.We effort to grow up individuals who has tolerance,understanding,respect for human rights and fundamental freedoms among all nations,racial and religious groups. There are swimming, chess, music and football clubs . Our students can choose a robotic club as well. Students of our robotic club take part in various

competitions and win prizes. During robotics lessons our students use LEGO Education WeDo2.0 sets. They make robots from lego blocks and programme they in a visual programming language, explaining the functions of blocks so that the robot can perform the required task.



1.2. Specific objectives of the project

Taking into consideration the above described rationale in Europe and the particular needs of the secondary schools, the specific objectives of the project "Innovative Schools: Teaching & Learning in DIGITAL STEM LABS" are:

SPECIFIC OBJECTIVE 1: To improve the competencies of secondary school teachers for the development of digital teaching methodology in line with the new applying of distance STEM education (innovations, smart specialisation, design-based innovation)

SPECIFIC OBJECTIVE 2: To enhance the provision of the STEM education at (lower/ upper-secondary) level through wider integration of digital contents into the school curriculum in full compliance with the distance learning and teaching.

In line with the above listed specific objectives of the project, the PRIMARY TARGET GROUP of the project are the teachers of general education subjects that are suitable for the crosscurricular/ interdisciplinary teaching of the topic of the STEM education at and its revitalisation at the European/national/local level, including related concepts digital education and participatory approaches, social innovations, smart specialisation, EU, funding instruments). Hence, the expected results linked to the SPECIFIC OBJECTIVE 1 of the project are as follows:

• RESULT 1.1: Enhanced competencies of secondary school teachers for developing thematic/cross-curricula contents in relation to online STEM education and related concepts (creativity & innovativeness, participatory approaches, technical innovations, smart specialisation) in an integrated way;

• RESULT 1.2: Ensured exchange of good-practices among the secondary schools-project partners regarding the teaching standards, innovative pedagogies and didactic materials used in crosscurricular investigation of STEM education and its revitalisation.

The RESULT 1.1 and the RESULT 1.2 of the project will be accomplished through implementation of the following activities:

• Delivery of the Intellectual Output 1 - State-of-the-art situation in STEM education concerning the digital readiness;

• Delivery of the Short-term joint staff training events (three targeted trainings)

• Pilot-testing of the Curriculum Framework "DIGITAL STEM LABS" under the Blended mobility of school learners (secondary school students from 3 partner schools)

Based on the existing good-practice examples as well as the new competencies/professional experiences that will be gained by the teachers of the general education subjects form partner schools, all the involved partner schools will be in a position to explore various crosscurricular/ interdisciplinary approaches that sufficiently reflect the multi-dimensional nature of the STEM education investigation in line with the contemporary standards and interdisciplinary approaches. In doing so, the cross-sectoral partnership of the project will fully take into account the realities of their respective national education systems and (where applicable) curricular reforms in Turkey, Spain, Greece and Lithuania. Hence, the expected results linked to the SPECIFIC OBJECTIVE 2 of the project are as follows:

• RESULT 2.1.: Curriculum Framework "DIGITAL STEM LABS" that enables effective embedding of the digitalized STEM contents into the school curriculum of the secondary schools/contextualized learning of the STEM education contents within the general subjects at the lower/upper secondary schools level is developed, pilot-tested and further disseminated;

• RESULT 2.2.: A comprehensive methodological guidelines that practically demonstrate core quality factors required for successful implementation "DIGITAL STEM LABS" and relevant teaching/learning (innovative pedagogies and didactic materials used in cross-curricular investigation of STEM education) are developed, pilot-tested and further disseminated.

The RESULT 2.1 and the RESULT 2.2 of the project will be accomplished through implementation of the following activities:

• Delivery of the (a) Intellectual Output 2-Development of the Curriculum Framework "DIGITAL STEM LABS", (b) the Intellectual Output 3 - Methodological guide to teach "DIGITAL STEM LABS" at the secondary school level and the Intellectual Output 4 - web-platform (Open Education Resource (c) dissemination by means of the web-platform (Open Education Resource on Educational Provision of the "DIGITAL STEM LABS").

• Pilot-testing of the Curriculum Framework "DIGITAL STEM LABS" under the Blended mobility of school learners.

The secondary target group of the project will be the secondary school students from the partner schools who will be involved in the blended learning/short term exchanges. They will improve their STEM skills/transversal competencies in close cooperation and interaction with their peers from other from other schools/European countries.

1.3. Project activities

The project/work plan is structured in 5 components / 5 project phases, each of them being divided in several activities with all the phases/components having strong interactions among them.

Component 1:

State-of-the-art situation in STEM education concerning the digital readiness

Given the diversity of the distance education best practice examples and relevant level of mainstreaming in the countries represented by the project partnership (Turkey, Greece, Lithuania, Spain) a comparative analysis will be undertaken. Relevant study/report will be as an Intellectual Output 1. This component of the project will be coordinated by Nezihe Derya Baltalı Bilim ve Sanat Merkezi (Turkey). Other project partners will provide relevant contributions/inputs.

Component 2:

Exchange of competencies and know-how / tailor-made trainings

The 2nd component of the project will be focused on extensive and direct exchange of competencies and know - how by means of Short-term joint staff trainings conducted by the

respective project partners and their external experts/key stakeholders on the following topics of :

- **Module 1 Science in STEM**- this module will be designed, organised and delivered by University of Crete;
- **Module 2 Technology-Engineering in STEM**- this module will be designed, organised and delivered by Pamukkale University
- **Module 3 Maths in STEM**- this module will be designed, organised and delivered by Rey Juan Carlos University.

Component 3:

Development of the Curriculum Framework "DIGITAL STEM LABS"

Based on the outcomes of the Component 1 and Component 2, the project coordinator and project partners will jointly deliver the Curriculum Framework "DIGITAL STEM LABS". The Curriculum Framework will be considered as an Intellectual Output 2. Following the delivery the Curriculum Framework the project partners will commence with the development of a comprehensive methodological guidelines for teacher which will demonstrate core quality factors required for successful implementation of relevant distance teaching and learning.

The methodological guidelines for teacher will be considered as an Intellectual Output 3. This component of the project will be coordinated by University of Crete (Greece) and Other project partners will provide relevant contributions/inputs. In parallel, a Web-based thematic platform, i.e. Open Education Resource (OER) on educational provision of the "DIGITAL STEM LABS" will be designed. The OER design and relevant development will be coordinated by Pamukkale University. Other project partners will provide relevant contributions/inputs. Open Education Resource (OER) will be considered as an Intellectual Output 4.

Component 4:

Pilot-testing of the Curriculum Framework "DIGITAL STEM LABS"

The pilot-testing of the Curriculum Framework " DIGITAL STEM LABS" will be carried out by by means of a short-term exchange of the secondary school students from 3 partner schools. The pilot testing will be designed and coordinated by Panevėžio Žemynos progimnazija, Panevėžys(Lithuania).

Component 5:

Dissemination of the Curriculum Framework "DIGITAL STEM LABS" and results of the pilot-testing

The final phase of the project will be focused on the dissemination activities as well as internal activities aimed at ensuring maximum impact and sustainability of the specific components/key outputs of the project. 3 national dissemination events/conferences will be organised in Turkey, Lithuania and Greece. Secondary schools from the respective countries (Turkey, Greece, Lithuania) Nezihe Derya Baltalı Bilim ve Sanat Merkezi, 3rd Junior High School of Rethymno and Panevėžio Žemynos progimnazija will be responsible for relevant organisation and facilitation of the events. A national dissemination event/conference for a minimum of 40 national participants will be organised in each country. Such conferences will be considered (in the jargon of the Erasmus+ KA 2 projects) as Multiplier Events.

2. About STEM Education

*"When life challenges you, it surely doesn't test your abilities to do maths, physics, chemistry, etc individually. Instead, it tests your abilities to handle the situation using the teachings of these subjects; the theoretical base with the practicality of life. This is where **STEM education** establishes its firm foot in the field of education to help the 21st-century population sail through life."*

With the rapid change in market trends and the nature of desirable skills in the workforce, the education sector has introduced STEM education, an acronym for well-known terms– Science, Technology, Engineering, and Mathematics. STEM education is a teaching and learning approach that is a unique combination of Science, Technology, Engineering, and Mathematics. To be precise, STEM education primarily focuses on hands-on and problem-based learning methodology. STEM emphasizes developing logical and critical thinking skills by allowing students to learn and understand things from the perspective of the real world. STEM education equipped students with the skills that are required to succeed in their respective careers whether it be in jobs, entrepreneurship, etc.

Coined by the US National Science Foundation in the 1990s, the STEM acronym, standing for "science, technology, engineering and mathematics" continues to be a source of ambiguity among practitioners, particularly in the area of education. Definitions of STEM range from simple referencing of the four discrete fields indicated in the acronym, to educational approaches at the intersections of any number of the four disciplines, to a fully integrated view of STEM education.

When STEM education is placed at the "intersection" of science, technology, engineering and mathematics, its meaning is usually expanded to refer to a rupture with "traditional" teaching.

An integrative STEM education usually implies multidisciplinary teaching and is directed at developing students' problem-framing and problem-solving skills, as well as their ability to contextualise scientific concepts to real-life situations. In this understanding, STEM education is not defined in terms of a break with traditional subjects, but rather with a break from traditional instruction, in which lessons are strictly focused on the delivery of subject-specific content by the teacher and the acquisition of content knowledge by the students.

At the level of European countries, however, there is no common understanding of what STEM refers to. In most national and international reports, STEM teaching is usually interchangeable with "science teaching", a term used to refer to "*all of physical sciences, life sciences, computer science and technology, and [...] includes mathematics – subjects that are commonly taught at primary and secondary schools in most European countries*" – in other words, to the various domains of knowledge covered by the acronym.

To avoid confusion between the various definitions of STEM and the various educational approaches that can be implicit in the acronym, for the purpose of this report, STEM was used to refer to all subjects which are included under the four domains of Science, Technology, Engineering and Mathematics, regardless of how they are approached in the classroom. The upcoming repot, focusing on STEM Education Practices, will shed a new light on the way STEM is approached in practice in classrooms throughout Europe.

2.1. Significance of STEM Education

With **STEM (Science, Technology, Engineering, and Mathematics)**, it is not the teaching of one subject but rather the amalgamation of all four subjects as a comprehensive one through an interdisciplinary curriculum. This helps students to deal with real-world situations and apply their learnings to create, innovate and discover new things. Also, it has been proven that

students who adopt the STEM learning approach have better possibilities of getting placed at good companies, achieving the goals of their life contributing to the environment, etc.

a. Enhance Critical Thinking

STEM education is a very important aspect of student's life as it teaches them to solve problems effectively. Students who are accustomed to STEM education at an early age learn to analyze challenges and are able to develop strategies to tackle them.

b. Motivates Experimenting

In the last couple of decades, it has been noticed that STEM education provides a healthy environment and encourages students to try new things. Children who are part of STEM education learn the importance of failure and how to tackle it without getting affected.

c. Teamwork

STEM education is best for team-building activities and it helps students from every level to work together. They come together and find solutions to the problem discuss with each other, record data, give presentations, write reports, etc. In the end, they come to know the importance of working with each other and, flourish in a complete team-building environment.

d. Boosts Curiosity

This is one of the most vital **features of STEM education**. Students who are made habitual of this type of education since childhood, develop curiosity and innovation as their regular habits. This type of education enhances the critical way of thinking and empowers them to ask questions.

e. Enhances Problem Solving Skills

With the enhancement of critical thinking, students also learn problem-solving skills. By **adapting STEM education from an early age** children learn the ways of examining problems. Children can also create amazing plans to solve problems. Also, it helps students to look at the bigger picture and not from the smaller aspect.

2.2. Digital STEM education – challenges and solutions

Digital materials to support the work of teachers and students are cutting-edge solutions that schools around the world are eager to introduce. What do digital materials mean in practice? The crucial is interactivity, a much better understanding of the content by students, engaging and interesting tasks, more pleasant work for teachers, and the possibility of learning anywhere in the world. Digital solutions are beneficial for science teachers, such as biology, chemistry, physics or geography, who no longer need to conduct difficult research live. Still, they can instead show it through a ready-made video or animation. A printed textbook is not able to present a complex chemical experiment or allow solving interactive exercises. Digital resources also mean the ability to adapt to imposed conditions simply. The transition to remote mode no longer has to be an unpleasant surprise because eContent can be presented both in the classroom on an interactive whiteboard and with the help of Zoom, Microsoft Teams or professionally with customized Learning Management Platforms. There is a variety of digital content that can be easily adapted to specific needs without printing multiple versions of the textbook.

Educational challenges of recent years

The digital world, which is getting closer to us every day, means that the education industry also has to decide to change. However, a significant obstacle for schools is the complexity of accessing proven academic materials in digital form. Therefore, the role of the publishers is to be the ones to provide the package of digital content they need. In addition, children are increasingly overstimulated. They need engaging, interactive content that will capture and hold their attention. A simple textbook or a static PDF is no longer enough. Many more interesting solutions are needed.

Children associate many aspects of everyday life with the digital world. The challenge for publishers and teachers is to show students that the Internet, the digital world, is a space where they can also find learning materials to facilitate the acquisition of necessary content. Nowadays, the results are as important as the time we take to achieve them. Another challenge for the school is to teach children to work efficiently, which will produce the desired results in a relatively short period. Digital materials help achieve this goal.

2.3. Teaching STEM – difficulties and proposed solutions

The changes happening in front of our eyes sometimes condition the difficulties associated with teaching these subjects. What do these complications look like and, most importantly, how to address them?

- Distance learning has become problematic for educational publishers, teachers, students and parents. Sometimes lessons conducted away from the classroom are no longer as engaging for students as those undertaken at school. Teachers don't have the opportunity to conduct experiments in front of students, and a simple lecture is no longer as understandable to them. Science subjects often require visualization of complex content. To solve this problem, we have to prepare simulations of chemical and physical experiments, which publishers can include in their textbooks, and thus make the created content much more attractive. In addition, the students themselves can create experiments following teachers' clues.
- Mathematical, physical or chemical operations are complicated in desktop and distance learning times. Explained by a teacher or read about in a textbook is often not enough to fully understand the material. To make textbooks created by publishers as user-friendly as possible for students and teachers, we have to create interactive exercises rich in experiments and processes that explain the issue step by step. This form is much more accessible, interesting, engaging, and facilitates knowledge retention.

- A teacher who wants to conduct his science subject in the most engaging way possible for the student has to spend a great deal of time searching for appropriate digital materials, such as videos, illustrations, and interactive exercises. Therefore, a material that would provide these right away would achieve a considerable advantage in the market. In ready-made digital resources for STEM subjects, publishers will be able find a whole range of additional resources, such as videos, illustrations, posters, AR/VR elements and animations.
- The changing education program and the requirements of schools pose another difficult challenge for publishers. Ready-made interactive materials, thanks to their abundance of knowledge, can be easily adapted to the local Curriculum. In addition, all content can be translated into the native language. STEM subjects will always be present in schools, and their specificity means that digital materials to support teaching will be in constant demand.
- Young generations of students are digitally oriented and the digital world is basically their natural environment. Unsurprisingly, they want their schools to go digital as well. They find the interactive way of imparting knowledge much more interesting and engaging. After all, science subjects can sometimes be challenging to understand, so digital materials are necessary to help teach them.
- Schools are increasingly keen on achieving high rankings, which ensures their growing popularity among talented students. And it is modern educational materials that lead to an attractive school offer that will become modern and attract capable and ambitious individuals, both students and teaching staff. It is a simple way to satisfy everyone and leads to a high position in the rankings. STEM subjects are crucial in educating future doctors and scientists ranging in all fields, so focusing on this particular group in specific is very important.

2.4. Why should we have digital STEM education materials?

Digital materials support the educational process at every stage and help everyone to be involved. They are important for entire schools and teachers, students and parents, who no longer have to worry about their children's learning engagement. Publishers using digital solutions are valued by schools and are eager to cooperate with them. However, creating such materials from scratch requires much work, digital knowledge and time. Time is precious in fast-paced technological changes. That's why we need to introduce digital solutions quickly and seamlessly. Here are some digital material suggestions:

VSL, or Virtual Science Laboratories. These are packages to help learn chemistry, biology, physics and geography.

Interactive Whiteboard Resources. These are digital kits for elementary schools that can also be used on a computer, tablet or smartphone.

ICONS, or Interactive Charts of Natural Science. A project designed for K-12 education in biology, physics, chemistry, and geography. ICONS contains a set of digital materials that can be used both in the classroom and during remote teaching..

All this digital material brings the publisher closer to modernization. The school helps educate new generations, and the students have a much more enjoyable experience during the knowledge retention process. They are helpful to anyone who works in the education sector. As well as being able to access learning anytime, from anywhere, digital education also **enables students to learn at their own pace**. They can re-read materials to gain a deeper grounding in a topic or even revisit earlier modules. Schools and schooling must adapt over time to meet the ever-changing needs of society, and the learners they serve. Informal learning contexts can motivate and engage learners by drawing on their interests and providing flexible social learning environments that promote active participation and meaningful learning through authentic activity. Conceptualizing, designing and creating products that meet real needs to address real problems provide excellent opportunities for learners to engage in the work of scientists, engineers, technologists and mathematicians and explore the relationships among them.

2.5. STEM education challenges and potential pathways for overcoming these challenges

In Science, Technology, Engineering and Mathematics Education Policies in Europe. Scientix Observatory report through consultations with Ministry of Education representatives and industry and university stakeholders, a number of STEM education challenges were identified. Potential pathways for overcoming these challenges were also proposed:

- Attracting more students and teachers to STEM education through a global approach from primary education to continuing professional development that will better anticipate the skills needed for the society of the future;
- Breaking the barriers between subjects with pragmatic initiatives (teacher training sessions, publishing contents, sharing best practices, etc.) to improve the quality of STEM education by building on each country's strengths;

- Evaluating and integrating curriculum and pedagogical innovations: all energies must be oriented in the right direction with value added purpose-built technologies and services that need to be provided; positive experimentations need to be rolled out across the entire education system and disseminated among European countries (sharing of best practices, ideally in line with a common European framework);
- Developing a common European framework of reference for STEM education and coordinating national STEM initiatives related to publishing pedagogical content to ensure teachers' needs are met;
- Fostering deeper collaboration with universities and industry to develop STEM teachers' skills.

  One of the main motivations for improving STEM education is the need to attract more students into STEM studies to provide the job market with adequate resources, in terms of quality and quantity. However, this motivation lacks a coherent and integrated approach:

  a. some countries are focusing on ICT for primary and secondary education, mainly coding projects (designing games, programming robots, etc.), which do not necessarily develop skills related to research and development activities that an engineer would require;

  b. the well-known fact that employers depend on universities that in turn depend on high schools to recruit STEM skilled candidates does not seem to inspire national STEM strategies, which involve an ambitious cooperation between these three types of actors.

There are silos and boundaries that segment the STEM block of subjects, especially between mathematics and sciences. Mathematics is prevalent in the STEM block – failure in this field is not an option for students who want to embrace STEM careers – but innovative and engaging pedagogical approaches seem to be developing faster in other STEM subjects. Sharing best practices between STEM courses should increase the quality of STEM teaching as well as the commitment and success of students in these paths, but it is a challenge to develop transversal approaches in teacher training and content publishing.

A truly harmonised national approach must be put in place to coordinate numerous and diverse partnerships or internal programmes in favour of STEM. STEM initiatives should be connected to the curriculum or fully integrated into schools' local strategies for measuring their impact on student success and therefore their overall efficiency. A "what works centre" on STEM initiatives and programmes is needed to study the major initiatives of this burgeoning sector and scale up those that impact positively. While a variety of approaches is needed, the lack of a coordinated approach also appears when one looks at the heterogeneous partnerships between high schools and universities and companies.

The creation of educational resources for teaching STEM no longer relies solely on the activity of traditional publishers. A trend has emerged where teachers themselves develop resources and share them with specialised communities. On the other side, NGOs and private companies are beginning to offer quality content that teachers adopt. This transition to a large supply of resources is observable in several European countries and encouraged by European Commission-funded programmes. Choosing between a diversity of STEM teaching resources available can prove challenging for teachers. Public stakeholders have not yet reacted adequately to this new situation: curation is not sufficient and a national content strategy should be implemented to define roles and responsibilities for the numerous actors concerned.

To develop STEM teachers' skills, governments could increase the involvement of universities and deepen partnerships with companies. University staff do not always feel sufficiently recognised when they participate in promoting STEM academic paths. Partnerships with private companies do not seem to be structured to take account of local stakeholders' points of view, although these private companies are the ones who are industrialising new technologies that will affect both teaching and learning. It is essential to define models and best practices on a European scale to generalise faster and wider dissemination of the training content needed by teachers. Governments could also use innovative propositions such as on-the-job training, mobile learning and micro-certifications. These new methodologies make training capabilities easier to access.

These five points reveal a major strategic issue. It is difficult to observe at present the implementation of an integrated strategy involving all the domains and actors concerned on a national or European scale. Of course, more data will become available as the STEM plans that are presently being developed in many countries are fully implemented.

To cope with the fast pace of technological innovation, European education systems need a better vertical integration of their STEM policies with better relations between schools, universities and companies recruiting STEM profiles. Researchers are developing new paradigms and technologies, companies are industrialising these discoveries: both are activities based on new devices and skills sets that teachers must master and convey to their students to prepare them for the job market.

European education stakeholders also need better horizontal integration to develop a balanced approach between the different parts of the STEM block to ensure that:

- the emphasis on ICT skills in primary and secondary education does not marginalise other STEM skills such as engineering;

- students' difficulties in mathematics do not negatively affect their motivation for experimental scientific inquiries;
- students or teachers are able to transition between different STEM domains to tackle scarcity issues locally or in specific STEM domains;
- industry develops education purpose-built technologies and services helping the academic world to acquire the skills needed to be competitive on the job market and fill the gap in STEM-related jobs currently foreseen.

Reference:

European Schoolnet (2018). Science, Technology, Engineering and Mathematics Education Policies in Europe. Scientix Observatory report. October 2018, European Schoolnet, Brussels.

3. Intellectual Output 1

Comparative study: State-of-the-art situation in STEM education concerning the digital readiness

Given the diversity of the distance education best practice examples and relevant level of mainstreaming in the countries represented by the project partnership (Turkey, Greece, Lithuania, Spain) a comparative analysis is undertaken with a view of mapping:

• Relevant European/national educational policy frameworks and practice in the field of valorisation, interpretation and appropriate presentation of STEM education

• educational provision of STEM education at the secondary education level in European Union and each of the partner country, including diverse higher educational programmes, specialized courses/summer schools as well as user-centered, open-innovation methods such as Living Lab method which connect academic activities of the institution (i.e. learning & teaching, and academic research) with non-academic partners/stakeholders through benchmarking analysis of the elements of the educational contents and relevant teaching/learning methodology that can be transferred into/adjusted to the needs of relevant curriculum framework at the (lower-upper secondary) level

• the integration of STEM skills in general education subjects lower/upper-secondary level that exist in the participating countries such as natural science subjects (maths, physics, chemistry and similar), information technology, etc.

• best practice curricular/methodological models for the integration of the digital STEM topics in general education subjects at the level (lower/upper-secondary) that exist in other European Union member countries such as natural science subjects (maths, physics, chemistry and similar), information technology, etc., practical teaching/learning arrangements in distance learning (e.g. STEM labs in cooperation with the employers/local community) etc. -through benchmarking analysis of the elements of the educational contents and relevant teaching/learning methodology that can be transferred into/adjusted to the school curriculum at the (secondary) level in Turkey, Greece, Spain, Lithuania respectively;

• More detailed needs of the organisations/entities in the field STEM education from the participating countries with regard to the adequate competencies of teachers in distance teaching/ learning;

• Possibilities/recommendations for the wider the integration of the STEM fields into the secondary school curriculum from the point of view of the current curricular reform that are taking/will be launched in Turkey, Lithuania, Greece and Spain respectively.

Relevant study/report is considered as an Intellectual Output 1 of the project.

Each partner organisation participated in the delivery of the Intellectual Output 1.

3.1. Methodology

Nezihe Derya Baltalı Bilim ve Sanat Merkezi is leading organisation in the preparation and delivery of the project's Intellectual Output 1. Nezihe Derya Baltalı Bilim ve Sanat Merkezi, which was named Intellectual output coordinator, communicated with partner organisations and their Intellectual output tasks leaders.

Nezihe Derya Baltalı Bilim ve Sanat Merkezi defined structure of the document and list of topics and tasks and made structure of relevant questionnaire for collecting data.

All partner institutions did their part of research and filling the form. After collecting all information, Nezihe Derya Baltalı Bilim ve Sanat Merkezi did analysis and summary all relevant information that could help in next activity, curriculum.

The process of conducting the comparative analysis is based upon the systematic application/combination of specific research methods, including a broad collection of primary data (questionnaires and interviews) and secondary data (existing literature/documents):

- Desk research of relevant national and European Union documents (e.g. policy frameworks/strategies in the field of valorisation, interpretation and appropriate presentation of STEM education; national strategies in the field of education, national curriculum, curriculum of specific higher education institutions in the participating countries that (in)directly cover STEM topics and analysis of the transferability into the secondary school curriculum; various STEM education research papers, relevant academic journals and academic literature; existing methodological guides developed under various initiatives and projects/EU-funded projects, existing teaching materials used at the higher education level, etc.);
- Questionnaires that is sent to relevant STEM experts and organisations/entities in the field STEM education in the involved countries;

• Semi structured interviews with the key representatives of organisations/entities in the field of distance education.

The findings of the comparative analysis/mapping of needs will be primarily used as a significant expert analysis/contribution/benchmarking tool for the delivery of :

• The Intellectual Output 2- Curriculum Framework "DIGITAL STEM LABS"

• The Intellectual Output 3- Methodological guide to teach "DIGITAL STEM LABS" at the (lower/upper-secondary) level

• The Intellectual Output 4- Web-based thematic platform - Open Education Resource on educational provision of "DIGITAL STEM LABS

INTELLECTUAL OUTPUT 1:

Comparative study: State-of-the-art situation in STEM education concerning the digital readiness

OUTPUT TYPE: Studies / analysis – Research study / report

Please read questions and fill the answers, if you have any questions, please write to me at durmazmunire@gmail.com You are free to attach photos, web links, charts.

As we agreed, I please you to send me answers till the end of September!

Country: _____

1. Please write information about your institution (general information, fields of interest, previous projects - EU, national, local).
2. Please write about previous experience of the institution with STEM education-projects, workshops (short description, web).

3. Please write about previous experience with STEM education- in everyday education in your institution.
4. Please describe what importance is for your institution to participate in the project INNOVATIVE SCHOOLS: TEACHING & LEARNING IN DIGITAL STEM LABS and to improve education about STEM education.
5. Please research and write about relevant policy frameworks in the field of valorization, interpretation and appropriate presentation of STEM education in your country.
6. Please research and write about relevant good practice/case studies in the field of valorization, interpretation and appropriate presentation of STEM education in your country in formal and informal education.
7. Please write examples of educational provision of STEM education at the secondary education level in your country, including diverse higher educational programs, specialized courses/summer schools, which connect academic activities of the institution at the higher education level. For example - learning & teaching and academic research, with non-academic partners/stakeholders through benchmarking analysis of the elements of the educational contents and relevant teaching/learning methodology that can be transferred into/adjusted to the needs of relevant curriculum framework at the (lower-upper secondary) level.
8. Please write about best practice curricular/methodological models for the integration of STEM skills in general education subjects at the lower/upper-secondary level that exist in your country - related to natural science subjects - (maths, physics, chemistry and similar), information technology, etc., practical teaching/learning arrangements in distance education.

9. Please write about possibilities / recommendations for the wider the integration of the STEM fields into the secondary school curriculum from the point of view of the current curricular reform that are taking/will be launched in Turkey, Lithuania, Greece and Spain respectively.
10. Please write about the detailed needs of the organisations/entities in your country in the field of STEM education with regard to the adequate competencies of teachers in distance teaching/ learning.
11. Please write about national strategies and current national curriculum in your country with regard to STEM education concerning digital education readiness (for example using SWOT analysis).
12. Please write about national strategies in the field of education, current national curriculum, and fields that (in)directly cover STEM education regarding the teaching standards, innovative pedagogies and didactic materials used in cross-curricular investigation of digital education.
13. Please write about the detailed needs of the organisations /entities /institutions /schools in your country in the field of STEM education with regard to the digital contents into the school curriculum in full compliance with the distance learning and teaching.

4. Türkiye

4.1. Nezihe Derya Baltalı Bilim ve Sanat Merkezi

Nezihe Derya Baltalı Bilim ve Sanat Merkezi is located in Pamukkale, Denizli, Türkiye. It was founded in 2001, as one of the peer science and art centers in Turkey. It is a governmental institution that provides supplementary education to the gifted. Our students are aged between 8-18. We have 701 students both in arts and general intellectual ability. We carry out a project-based education and curriculum special to these pupils individually or in small groups of max 8. Following contemporary trends and changes in education, all our teachers continuously work on their professional and personal development, visiting and organizing numerous seminars, trainings, presentations, participating in the preparation of various projects and competitions in the country, with the aim of providing high quality and more creative services to those for whom this institution exists, and these are our students.

For the same reason, the school is equipped with modern teaching and support tools, both in IT lab and in cabinets for: mathematics, biology, geography, chemistry, physics, informatics and robotics. There is a multimedia classroom, a festive hall, a media library, and the modernization of the other classrooms follows. We have interactive boards in all classrooms. We strive to enrich life in school with various creative and imaginative contents of educational, cultural, humanitarian and entertainment character. We do this through the realization of numerous sections, extra-curricular activities, national and international projects, participation in eTwinning projects that got National and European Quality Labels etc. The school was awarded eTwinning School Label in 2019-2020 Academic Year.

Nezihe Derya Baltali Bilim ve Sanat Merkezi is highly regarded for:

- A broad curriculum including career advice;
- The use of ICT tools to enhance the engagement of, and successful outcomes for students;

- Science, Technology, Engineering and Mathematics (STEM), Literacy and Numeracy;
- STEM project-based learning activities that can be tailored to meet your students' needs.

STEM at Nezihe Derya Baltali Bilim ve Sanat Merkezi is committed to:

- Developing an engaging curriculum for STEM subjects;
- Providing teachers with relevant skills and resources to support student learning;
- Giving students opportunities to participate in activities, events and other initiatives;
- Increasing retention in STEM subjects;
- Developing pathways to post school employment and Careers in STEM industries.

4.2. Previous experience with STEM education - projects, workshops

Our experience with STEM education is not very extensive but there have been some interesting projects that we organized in previous years and our school has also applied for some new projects, closely related to this topic. Four of the European projects we have developed in the last years were connected with (mainly) STEM education:

a) Project **"Social Values STEM from European Heritage"**, whose objective is to promote & ensure the recognition of the social, economic & educational value of the EU cultural heritage by promoting interdisciplinary co-operation in STEM. The project partnership aims to develop basic STEM skills & knowledge through cross-curricular CLIL & ICT approaches. Another objective of the project is to promote interdisciplinary co-operation in STEM to address the problem of lack of motivation for the study of STEM. The projects also aims to support effective and innovative pedagogies along with teaching in order to contribute to the teachers' professional development. The most important results of our Erasmus+ project "Social Values

STEM from European Heritage" are the 3 handbooks published in e- format available at the following links:

http://lectura.bibliotecadigitala.ro/?p=4411 - Volume 1

http://lectura.bibliotecadigitala.ro/?p=4924 - Volume 2

http://lectura.bibliotecadigitala.ro/?p=5386 - Volume 3

With hope that these e-books will reach as many as possible interested teachers, students, parents, other interested people.

b) Project **"Sound (STEM) all around"** whose objective is to engage students to study STEM fields, intertwining all scientific fields as well as life phenomena. The project aims to create a synergy of socio-humanities, art and STEM fields. We intend to do this by connecting socio-humanities, art and STEM subjects through a series of workshops, experiments, research, presentations and contemporary teaching methods, and through the use of various digital tools. We organized workshops through teaching and extracurricular workshops in physics, maths, geography, history, philosophy, music, religion, and drama. That is why we want to develop the basic skills of students in literacy, language, digital and communication skills through innovative interdisciplinary learning by linking the STEM area with the socio-humanist and artistic area. This experience can have a major impact on student future work, faculty selection and employment as active European citizens. Through the project we want to share experiences with other pupils and teachers from partnering schools and promote international heritage and culture. More information of the project can be attained in the following link:

https://soundstemka229.wixsite.com/website

c) Project **"From robotics to the ethics of technology: the new concept of human rights"** The general objective of this project is, primarily, to systematise and share the best practices for teachers and students in the field of technological ethics related to artificial intelligence and robotics contextualised in a human rights framework. Secondly, to develop introductory

activities of robotics in a practical scenario, such as basic robotic building and coding, in order to empirically introduce teachers and students to this new field and STEM education. The objectives of this project follow the European strategy and policy regarding Erasmus+, since this project developed key information and communication technology skills (ICT) in a transnational level by sharing best practices and practical knowledge that was disseminated into each school and its local community. The project partnership created a European Digital Manifesto based on videos and images developed by the students about the practical implications of robotics, artificial intelligence and technology for the 21st century as regards to 3 main areas: (i) robotics and human rights, (ii) robotics and economics, (iii) robotics and

health. This objective is linked to the horizontal objective of developing innovative and open practices in the digital era since the Digital Manifesto is available in the digital world for other European students. The methodology of this project is a hybrid model between theory and practice by using theoretical basic concepts that is problematised through practical approaches. In the first place, all the beneficiaries know more about the moral foundations of technology through non-formal education methodologies such as brainstorming, moral dilemmas, debates etc.

c) Project **"Creative Teens"** is about bringing Art into the lives of high school students. Firstly, there is growing evidence that learning arts does improve academic achievement. Studies have shown that when STEM approach is combined with teaching Art, students tend to achieve better results in general because arts cultivates cognitive abilities. Furthermore, arts also develop a more positive attitude towards school, nurture positive character traits, and foster critical thinking. STEAM education in schools provides students with the opportunity to learn creatively, using 21st century skills such as problem solving and critical thinking. These general capabilities are crucial to growing a future-ready workforce. Secondly, the project wants to emphasize that the purpose of the Arts Education is not to simply boost academic results. Immersed in arts,

students experience the world and themselves in a different way. They often discover a lifelong passion, develop a sense of self and identity, grow in confidence, and envision a world beyond their immediate environment. To sum up, art helps create creative, self-confident, emphatic individuals who can view the world in a critical way and who will bring value to their workplace. But it also helps people appreciate culture, understand their national and global identity and open up to the world. Investment in art is investment in creative industry, individual cognitive development and in the quality of life.

Therefore project partners decided to start a project which focus on art, precisely on Literature and Drama, and combine it with IT and design. The idea is to present the students with two challenging tasks: writing a book and creating a theater play based on the book. It is a three-year process, divided into two modules and many smaller steps that helps the students to achieve the goals with the help of their mentors. More information of the project can be attained in the following link: https://erasmus-create.eu/

4.3. Previous experience with STEM education - in everyday education

The topic of STEM education is to a certain extent covered by general subjects curriculum in all countries represented in this project (Turkey, Greece, Lithuania, Spain) through a cross-curricular approach. For example, Turkish curriculum of the secondary school covers certain elements of STEM education by means of the cross-curricular within the framework of the following general education subjects: Technology & Design, Physics, Science, Chemistry, Maths and Biology. In Turkey, the Education Information Network (EBA) portal has facilities for STEM teachers to share their STEM project activities and lesson activities (videos, documents, etc.). However, the curriculum of all these general education subjects does not sufficiently reflect the multidimensional nature of the STEM education. In general, several general education subjects in Turkish secondary schools curriculum address the fundamentals of STEM education and provide secondary school students with theoretical knowledge. However, the digital prerequisite contents related to STEM education are, to a large extent, insufficient and the development of specific pedagogical and online learning resources is needed urgently.

The theoretical possibilities for the introduction of themes related to STEM education investigation and its integration in European schools by means of the a cross-curricular approach have been tackled by a number of the multilateral initiatives/projects that were funded by different EU programmes in Turkey; however they have so far not resulted in concrete, "tangible" impacts in terms of meeting the needs of the secondary school practitioners in Europe for putting STEM education investigation and its integration to the curricular agenda of the secondary schools, or in terms of ensuring further capacity building activities of the teaching staff.

In Nezihe Derya Baltali Bilim ve Sanat Merkezi, we carry out a project-based education and curriculum special to gifted students. Learning environments are student-centered, project-based, and personalized. Our institution has developed innovative instructional models that create learner-centered and project-based STEM learning environments. Students have opportunities to direct their own learning and demonstrate STEM knowledge by undertaking complex projects. Such practices are grounded in contemporary understanding of how people learn. They also use evidence-based teaching strategies, such as complex instruction, inquiry-based learning, and culturally responsive pedagogies.

LEARNER-CENTERED

In this approach, the learner is at the center of all planning and actions. Learning environments intentionally build communities of practice between students and faculty, recognizing that learning is a social act that includes guidance and mentoring. The advisors strive to create rewarding interactions that enhance learning for all. They mitigate the mindset that STEM disciplines are difficult and appropriate for only some to pursue. All student groups enter learning environments that are culturally and linguistically relevant to them, and that are engaging and welcoming.

PROJECT-BASED

Project-based learning allows students to acquire knowledge and skills, to practice inquiry across multiple disciplines, and to make meaningful connections across STEM disciplines, medicine, the social and behavioral sciences, and the humanities. Project-based learning often focuses on real-world problems that can have significant social impact across society. A common thread among our advisors is the participation of our students in meaningful projects that require STEM concepts. This participation varied from projects in single courses to capstone projects that span the entire curriculum.

The advisors also changed their assessment and grading practices to align with this emphasis on project-based learning. As a result, learning becomes driven by students' motivation and their demonstrated capacity to learn, rather than mastery of specific STEM content alone, or by high-stakes examinations that determine course grades. From performance-based assessments with rubrics that help students develop competencies over time, to evaluations based on portfolios of student work, the innovators offer many opportunities for students to complete complex, technology-based projects with a variety of approaches to evaluations and grades.

PERSONALIZED

The advisors strongly feature self-directed learning. In our center, students start with a project of personal interest and decide how to acquire the knowledge needed to solve the problem, whether enrolling in classes, seeking mentoring, or accessing information through other means. Several advisors have eliminated practices that sort students into groups based on background or prior knowledge. Differences in foundational knowledge are instead mitigated individually through faculty mentoring or other strategies, allowing students to engage in self-directed learning based on individual preferences and pacing in a personalized way.

4.4. Participation in project Innovative Schools Teaching&Learning in DIGITAL STEM LABS

There are many reasons why we decided to organize and coordinate this project. First of all, there is a great need for more prominent introduction of the STEM education (valorisation/interpretation and presentation) on cross-curricular agendas of our institution. This project is one excellent and efficient opportunity to acquire this goal.

As one of the specific objective of the project is to improve the competencies of secondary school teachers for the development of digital teaching methodology in line with the new applying of distance STEM education (innovations, smart specialisation, design-based innovation), our teachers and advisors will benefit a lot from the project. There will be an

enhancement of the competencies of secondary school teachers for developing thematic/cross-curricula contents in relation to online STEM education and related concepts (creativity & innovativeness, participatory approaches, technical innovations, smart specialisation) in an integrated way. Also, there will be an ensured exchange of good-practices among the secondary schools-project partners regarding the teaching standards, innovative pedagogies and didactic materials used in crosscurricular investigation of STEM education and its revitalisation.

Another specific objective of the project is to enhance the provision of the STEM education at (lower/ upper-secondary) level through wider integration of digital contents into the school curriculum in full compliance with the distance learning and teaching. Based on the existing good-practice examples as well as the new competencies/professional experiences that will be gained by the teachers of the general education subjects form partner schools, all the involved partner schools will be in a position to explore various crosscurricular/ interdisciplinary approaches that sufficiently reflect the multi-dimensional nature of the STEM education investigation in line with the contemporary standards and interdisciplinary approaches. In doing so, the cross-sectoral partnership of the project will fully take into account the realities of their respective national education systems. Delivery of the Curriculum Framework "DIGITAL STEM LABS" that enables effective embedding of the digitalized STEM contents into the school curriculum of the secondary schools/ contextualized learning of the STEM education contents within the general subjects at the lower/upper secondary schools level will be a great asset for our institution.

Furthermore, through this project we intend to encourage our students to develop a lot of practical and useful knowledge. With the participation in the project, students will gain many know-hows, learn how to do research, propose solutions for investigation, evaluate and recognize opportunities for improving. This type of educational project is complementary to

classroom-based education, giving a fresher approach to learning, obtaining innovative and more efficient education, contributing also to our school's tendency towards being different.

Another advantage of this projects is providing opportunity to see how other European countries deal with this issue. Is there any similarity to our experience, which are specific differences, did others manage to introduce STEM education and what are the best practices from which we could gain some experience and suggest it to our local community and authorities? The answer to these questions would be of great significance to our school and our society in general.

The cooperation with other institutions which already try to provide solutions is also a benefit for us. Their experience and their educational activities are going to be an important guideline for us in creating our own materials and defining methodology in the curriculum which is to be the product of this project.

Finally, the purpose of the establishment of science and art centers, gives us an additional motivation to launch this project. Since science and art centers' primary purpose is to help gifted children develop their abilities, our institution enables the training of talented individuals, focusing on discovering the talents of the future today.

4.5. Relevant policy frameworks in the field of valorisation and interpretation and appropriate presentation of STEM education in Türkiye

The term STEM comes from the combination of the initials of science, technology, engineering and mathematics in its original language. It is also called FeTeMM (Science, Technology, Engineering, Mathematics) in our country. In South Korea, STEM, which is obligatory at all levels, is integrated with art and an art element is added and applied in the form of STEAM. In addition, abbreviations such as ESTEM, STEAM, S-TEAM are used instead of STEM. The letter "A" here is used as an abbreviation of the concept of "Art", which also includes aesthetics. The letter "E" in ESTEM represents the abbreviation of the word enterpreneur, that is, the concept of "entrepreneurship".

Although not under the name of STEM in the recent past in Turkey, Village Institutes are a good example of STEM work. The transition to the constructivist approach as a curriculum in 2004 can be perceived as the first concrete steps of STEM mindset. Because STEM thinking, which is based on practice, can be realized with an application and learner-centered constructivist approach. Until 2016, there is no official STEM action plan prepared in Turkey. However, since 2004; STEM is addressed in some reports prepared by institutions such as TUBITAK, Ministry of Development, TUSIAD, MEB and Istanbul Aydın University. In 2016, the Ministry of Education General Directorate of Innovation and Educational Technologies published the "STEM Education Report", revealing what needs to be done to include STEM in the Turkish education system, and an action plan of nine items was prepared (Türk, 2019: pp. 62-63; MEB, 2016).

STEM education is seen more prominently in the Science Curriculum prepared by the Ministry of National Education in 2018. In the new curriculum of the Ministry, starting from the 4th grade, in the Science course curriculum, the target is "to help students establish the connection between engineering and science, to understand the interdisciplinary interaction and to develop a worldview by making what they have learned experiential". In the same program, it is stated that "It is important for students to experience science and engineering practices in order to increase the scientific research and technological development capacity, socio-economic development and competitiveness of our country. Within the scope of Science, Engineering and Entrepreneurship Applications in the program, students are expected to define a daily need or problem related to the topics covered in the units. It is desired that the problem is aimed at improving the tools, objects or systems used or encountered in daily life. In addition, the problems should be handled within the scope of material, time and cost criteria." These statements indicate that STEM is prominently included in the curriculum. (MEB, 2018: p.10).

Reference: https://ekipedu.com/stem-nedir-dunyada-ve-turkiyedeki-gelisim-sureci-nasil-olmustur/

4.6. Relevant good practices and case studies in the field of valorisation and interpretation of STEM education in Türkiye in formal and informal education

In Turkey, there is no strategic action plan prepared by the Ministry of National Education for STEM education in 2015 and before. In the report published by the Turkish Industry and Business Association-TÜSİAD (2014), it was observed that there is a difference in company field contributions from those working in the STEM field and those working in non-STEM fields. As a result of the report, it was stated that a plan should be made to create employment for STEM fields, to increase the number of students who will receive education in STEM fields, and to increase the STEM skills of students at all levels of education. The Ministry of National Education has included objectives for strengthening STEM in its 2015-2019 Strategic Plan. Our country could not reach the expected results in exams such as TIMSS and PISA. In order to increase these results to the expected level, STEM education is an important approach that should be given priority in our country (MEB, 2016).

A study called **A Study on the Status of Research on STEM Education in Turkey** was conducted. With this study, a total of 97 studies, including 52 articles and 45 postgraduate theses, made between 2010 and 2018 on STEM education in the national literature were included in the research. Considering all these studies, it is understood that STEM education has an increasing importance in our country. As a result of examining the distribution of studies on STEM by years, it has been determined that since 2010, the most studies on STEM education in our country were conducted in 2018. No postgraduate thesis in the field of STEM in Turkey was found before 2014. It can be said that this situation arises due to the Engineering Applications included in the Science curriculum in 2014 and the changes made in the program content related to STEM fields. In addition, the report prepared by TÜSİAD (2014) and the mention of the aims of strengthening STEM in the 2015-2019 Strategic Plan also increased the interest in this field and revealed the need for STEM-related studies. For these reasons, it can be said that there has been an increase in research on STEM education in the literature after 2014.

Reference: https://dergipark.org.tr/tr/download/article-file/1147777

A Study on **Studies on STEM Education in Turkey: A study called Meta-Synthesis Study** was conducted. In this research, which was published online in 2020, a meta-synthesis study was conducted in which the studies conducted between the years 2014-2019, when the studies on STEM education started to intensify in Turkey, and as a result of this study, 58 studies were reached.

When the studies were examined, some dimensions for STEM education emerged.

-The first dimension focuses on increasing the interest and skills in STEM fields within the framework of 21st century skills, with STEM practices of secondary and high school students in or out of school.

- The second dimension emerged during the examination of the studies that discussed the current situation at the cognitive level for STEM. This dimension focuses on determining the perceptions of students, pre-service teachers and teachers about STEM education, their awareness levels and their views on STEM education after studies such as professional development programs and STEM applications.

-The third dimension focused on revealing the current situation for teacher candidates to establish relationships between STEM disciplines.

Reference: https://dergipark.org.tr/en/download/article-file/1000172

In a study conducted by TUSIAD under the name of **STEM Requirement in Turkey Towards 2023**, studies on stem in Turkey are summarized as follows.

Reference: https://tusiad.org/tr/yayinlar/raporlar/item/9735-2023-e-dog-ru-tu-rkiye-de-stem-gereksinimi

In Turkey, studies were carried out to raise awareness in STEM fields and to meet educational needs.

Examples of these are:

• The "School-Industry Cooperation Istanbul Model" project was implemented by the Istanbul Provincial Directorate of National Education. According to this project, "it has started to be carried out with the cooperation of all businesses and institutions, chambers, non-governmental organizations and universities that are representatives of the sector that need a qualified workforce." With this model, it is aimed to develop the technological infrastructure in schools, to share the experiences of enterprises with students and to develop an employment-oriented perspective.

• STEM education is implemented in Bahçeşehir Schools and higher education STEM fields are supported. In addition, STEM research is carried out by the STEM Center (BAUSTEM or FeTeMM) established at Bahçeşehir University.

• Hacettepe Science, Technology, Engineering and Mathematics Education and Applications Laboratory (Hacettepe STEM & Maker Lab) has been established since 2009 to support Turkey's scientific research and technological development capacity and its social and economic development. This laboratory carries out projects that support an innovative educational approach. These projects are; Science – Advanced Practices in Teacher Education (S-TEAM), Assessment Strategies in Inquiry-Based Science Learning (SAILS), and Mathematics and Science for Life (MASCIL).

• Istanbul Aydın University Educational Sciences and Technologies Center STEM School was established in 2015. The aim of this school is to increase the competencies of teachers and students in STEM fields and to contribute to the transformation of schools into STEM schools. "STEM Teacher Certificate Program" was implemented by this center.

• Openfab Istanbul, which was established with the aim of producing a generation at the STEM Academy within Özyeğin University, provides maker (coding, robotics, electronics, etc.) training for children aged 6-12.

• Stem&MakersFest Expo is organized every year as a conference and event on STEM with participants from different universities. There are PDStem applications for STEM project application created with the participation of academicians from many different universities.

• BİLTEMM, within the body of the Middle East Technical University (METU), was established to develop education opportunities and policies in the fields of Science, Technology, Engineering and Mathematics. It provides teacher workshops, projects and training to improve schools, teachers and the educational opportunities available to students.

• A STEM Education Report was published by the Ministry of National Education, General Directorate of Innovation and Educational Technologies (YEĞİTEK), and a model was proposed for the transition to STEM Education in our country.

According to the STEM report prepared by the Ministry of National Education, General Directorate of Innovation and Educational Technologies (YEĞİTEK):

TÜBİTAK's (Scientific and Technological Research Council of Turkey) 2011-2016 Science and Technology Development Plan includes some activities to support STEM education of students). 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. TÜBİTAK conducts project studies and organizes competitions in order to reveal successful students and teachers in STEM education. In addition, science centers have started to be opened in various provinces by TUBITAK regarding STEM education in our country. 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).

Studies and projects related to STEM education in universities in our country are not very common. The studies carried out to increase STEM education skills with trainings that strengthen the integrated teaching knowledge that teachers and prospective teachers will receive within the scope of in-service training and education faculties are very insufficient. In our country, STEM centers have started to be opened in which students and teachers can reach, in order to switch to STEM education. Hacettepe University and Istanbul Aydın University made the first attempts in this regard. On the other hand, the General Directorate of Innovation and Educational Technologies has been included as a national support point since 2014 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. The Scientix community is open to teachers, researchers, policymakers, families, and anyone interested in STEM education. The Scientix project continued as Scientix 2 between 2013 and 2016. It will continue as Scientix 3 from 2016.

When the curricula applied in our country are examined, the following themes are reached regarding the courses for STEM education: In the Science Curriculum, it is aimed to raise students as scientifically literate individuals with the knowledge, skills, perception and Science-Technology-Society-Environment (FTTC) learning area (TTKB, 2013) . While emphasis is placed on interaction with science, technology and society in the curriculum, it is seen that STEM integration and the field of engineering are not directly involved (Kertil & Gurel, 2016).

Science Applications course has been offered as an elective course for all levels of secondary schools by the Ministry of National Education since the 2012-2013 academic year. The aim of the science applications course is to raise individuals who are scientifically literate within the framework of the achievements in science lessons. Thus, the student will research the fields of science and improve himself by reading books and articles related to this field. Students who know how to acquire knowledge will understand the nature of science and it will be easier for them to grasp the scientific basis of the problems they encounter in their lives (MEB, 2012).

Most STEM education is practice-based and group-based. For this reason, course materials are needed in line with the requirements of such course activities based on inquiry, research, product development and invention. They are course materials that will contribute significantly to STEM education activities that aim to develop skills such as development and invention. Therefore, it can be said that FATIH Project and EBA create a favorable environment for STEM education.

FATIH Project is carried out by the General Directorate of Innovation and Educational Technologies of our Ministry. Within the scope of the FATIH Project, interactive boards, broadband internet infrastructure and access, and a tablet computer set for teachers and students are provided to all classrooms in public schools for the effective use of IT (information technology) tools in the learning-teaching process in order to increase the quality of education and training and to ensure equality of opportunity. In addition, many electronic content is put into service under the Education Information Network (EBA) to be used in lessons.

Reference:https://www.academia.edu/28944519/TURKIYEDE_STEM_E%C4%9E%C4%B0T%C4%B0M%C4%B0_NEREYE_GIDIYOR_STEM_ARASTIRMA_RAPORU_Milli_E%C4%9Fitim_Bakanl%C4%B1%C4%9F%C4%B1_Yenilik_ve_E%C4%9Fitim_Teknolojileri_Genel_M%C3%BCd%C3%BCrl%C3%BC%C4%9F%C3%BC

AN ORGANIZATION NAMED "STEM EDUCATION ASSOCIATION OF TURKEY": http://stemtr.org/

THE OBJECTIVES OF "THE TURKISH STEM EDUCATION ASSOCIATION" ARE:

• To create a national framework for STEM-related cooperation between the Ministry of National Education (MEB), the Council of Higher Education (YÖK), universities, industrial organizations, non-governmental organizations and schools on STEM.

• To carry out research, development and project studies at K-12 levels, to evaluate the data obtained, to reveal new STEM-based education models and to create programs suitable for these models, to integrate the created programs into the national curriculum.

• To follow, research and evaluate the studies carried out in the world in STEM fields. To share the results obtained with the public and the authority.

• To prepare regional, national and international programs in STEM fields; giving lectures, organizing events such as seminars, symposiums, panels and conferences

4.7. Examples of educational provision about STEM education at the secondary education level, including higher educational programs

It is a curriculum that directs states and schools about which achievements in science are taught and how, within the scope of the National Science Education Standards published in the USA in 1996. (National Research Council., 1996, akt. Akgündüz, and others, 2015). This program has found great response both in the USA and in the developed and developing countries of the world. The aim of this program is to provide students with an inquiry-based learning experience in the classroom. The European Union (EU) published a report called "Science Education Now: Renewed Pedagogy for the Future of Europe" in 2007 (Rocard ve ark., 2007, akt. Akgündüz, and others, 2015). In the report in question, the problems of Europe in science and technology education were emphasized and it was determined that the interest of young people in the fields of science, technology and mathematics decreased significantly. (Akgündüz, and others, 2015). In the report; It has been stated that communication networks for teachers should be established in order to ensure that science teaching is based on inquiry, to ensure cooperation among stakeholders in the field of science teaching, and to increase their motivation. Programs and projects have been initiated in the USA and EU countries to present an educational approach that gives priority to the needs/skills of modern business life, the philosophy of the education to be given, technical knowledge and skills, preparing students for life. (Akgündüz, and others, 2015). The newest of these applications is STEM education and applications.

(Gülhan & Şahin, 2016). In our country, STEM education, which is called STEM by making the abbreviations of the words Science, Technology, Engineering and Mathematics.

STEM education gives students enrich their physical, intellectual and cultural world and develop their self-efficacy such as critical thinking and problem solving. (Çorlu & Aydın, 2016). When student enters the business world, thanks to these superior skills, they can easily adapt to the qualifications required by business life. STEM education has emerged because it can meet these needs and approach problems with a holistic perspective. (Bybee, 2011). STEM education aims to enable students to look at problems from an interdisciplinary perspective and to gain knowledge and skills with a holistic education approach. (Şahin, Ayar, & Adıgüzel, 2014). STEM education is an interdisciplinary approach that covers the entire educational process from pre-school to higher education.

Although there is no direct action plan prepared by the Ministry of National Education for STEM education in our country, there are aims to strengthen STEM in the 2015-2019 Strategic Plan. It is seen that STEM objectives overlap with the Technology and Design DeArsi objectives to a certain extent. It can be said that the studies carried out at the 7th and 8th grade levels within the scope of Technology and Design course are for STEM. It has been determined that the average employment rate of graduates of STEM education fields is 19%. (TUSIAD, 2014). When the data of ÖSYM are examined, it is seen that the rate of graduates from STEM field in Turkey is 19%. (OSYM, 2014). TÜSİAD (2014) also emphasizes that STEM education is important for our country and that a STEM education strategy should be determined. In this strategy, it is necessary to plan activities to increase the number of students who will receive education in the field of STEM and to create employment in this direction. In addition, research and development investments should be supported in order to carry out innovation studies. In the field of education, with the transition to STEM education, students have a more qualified education and the 21st century. They are expected to acquire skills (problem solving, critical thinking, etc.). (TUSIAD, 2014). 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, science centers have started to be opened in various provinces by TUBITAK regarding STEM education in our country. 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 Akademi, 2013).

Science Applications course has been offered as an elective course for all levels of secondary schools by the Ministry of National Education since the 2012-2013 academic year. The aim of the science applications course is to raise individuals who are scientifically literate within the framework of the achievements in science lessons. Thus, students will research the fields of science and improve themselves by reading books and articles related to this field. Students who know how to acquire knowledge will understand the nature of science and it will be easier for them to grasp the scientific basis of the problems they face in their lives.

STEM Projects in Türkiye:

-Young Inventors Design the Future: Science, Technology, Engineering and Mathematics (STEM) Education" project

-Aydın University in İstanbul, In April 2014, it started the STEM for Disadvantaged Students Especially Girls Project to increase the interest of socioeconomically disadvantaged students and especially girls in STEM fields.

-Science Applications course has been offered as an elective course for all levels of secondary schools by the Ministry of National Education since the 2012-2013 academic year.

-The interactive whiteboards, tablet computers and Education Information Network (EBA) contents provided to schools within the scope of the FATIH Project also enable students to make inquiries, research, product development and invention.

They are course materials that will contribute to STEM education activities aiming at improving the ability to do.

-Experimental workshops in Türkiye

-Many science centers (Konya, Kocaeli, Bursa, etc.) were opened with the support of the central and local government and the initiatives of TUBITAK, and many students were hosted.

-Science and Art Centers; They are institutions opened to enable gifted and talented students to use their individual talents at the highest level. A five-stage training program is implemented. Students are separated according to their interests and abilities and they prepare projects according to their interests. In general, original products, projects and productions are realized in BİLSEMs.

4.8. Best practice curricular/methodological models for the integration of STEM skills in general education subjects at the lower/upper-secondary level that exist in Türkiye, practical teaching/ learning arrangement in distance education

Studies and projects related to STEM education in universities in our country are not very common. (Çorlu, 2013). The studies carried out to increase STEM education skills with trainings that strengthen the integrated teaching knowledge that teachers and prospective teachers will receive within the scope of in-service training and education faculties are very insufficient. In our country, STEM centers have started to be opened in which students and teachers can reach, in order to switch to STEM education. Hacettepe University and Istanbul Aydın University made the first attempts in this regard. On the other hand, the General Directorate of Innovation and Educational Technologies has been included as a national support point since 2014 in the Scientix Project conducted by the European Schoolnet on STEM education. Project Scientix (community project for science education in Europe) managed by the European Schoolnet (EUN) representing the European Commission. Started in December 2009, Scientix Project website "http:// http://www.scientix.eu/" 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. The Scientix community is open to teachers, researchers, policymakers, families, and anyone interested in STEM education. The Scientix project continued as Scientix 2 between 2013 and 2016. It will continue as Scientix 3 from 2016.

The main objectives of the Scientix Project are as follows;

- To ensure that the whole of Europe is aware of the many projects related to Science, Technology, Engineering and Mathematics (STEM) education taking place in Europe,

- To facilitate the dissemination and sharing of materials and tools produced after these projects,

- To create a platform where national congresses, conferences, workshops or projects held in European countries can be announced throughout Europe,

- To create a platform where teachers and academics across Europe can share their experiences and exchange ideas,

- To present examples of educational materials suitable for inquiry-based education that Science and Mathematics teachers can use in their lessons,

- Contributing to the training of teachers in the field of STEM education through online and face-to-face training,

- It is to identify the curious, questioning, talented students studying in primary and secondary schools and to direct them to the fields of Science, Technology, Engineering and Mathematics in universities and encourage them.

Within the scope of the Scientix project, various studies (conference, meeting, workshop, promotion, information, training, etc.) have been successfully carried out all over our country within the General Directorate of Innovation and Educational Technologies, and the third phase of the project started as Scientix 3.

it has been reported that thesis studies on STEM education are carried out in some universities. The following are the doctoral theses completed on STEM education in our universities so far.

(YÖK Thesis Center, 2017):

-Examining the effects of science, technology, engineering, mathematics (STEM) applications and mastery learning integrated into the seventh grade science course, Bekir Yıldırım, 2016, Gazi University

-The effect of science, technology, engineering and mathematics (STEM) education-based activities on the critical and creative thinking skills of pre-service science teachers, Yasemin Hacıoğlu, 2017,

Gazi University The master's theses that have been completed in our universities so far are as follows (YÖK Thesis Center, 2017):-A study on the preparation of an instructional design with science, technology, engineering and mathematics approaches on acids and bases in secondary school science course, 2014, Sevil Ceylan, Uludağ University -
The effect of STEM applications on fifth grade students' inquiry learning, motivation and academic success in the unit 'Let's Travel and Know the Living World', Eda Salman Parlakay, 2017, Mustafa Kemal University-Training young mechatronics using stem education model approach in science course, Yusuf Koç, 2017, Istanbul Gelişim University
-The effect of after-school activities with science, technology, engineering and mathematics (STEM) on students' achievement and STEM perceptions, Zehra Irkıçatal, 2016, Akdeniz University. 13 (21%) of the education faculties have faculty members who have done their doctoral studies in the field of STEM education. These universities are Aksaray, Bahçeşehir, Balıkesir, Boğaziçi, Bülent Ecevit, İstanbul, Karadeniz Teknik, Kahramanmaraş Sütçü İmam, Muğla Sıtkı Koçman, Muş Alparslan, METU, Osmangazi and Yüzüncü Yıl universities. In education faculties of six universities (10%), faculty members contributed to the field of STEM by publishing books in the field of STEM. These universities are Boğaziçi, Bahçeşehir, Hacettepe, Istanbul Medipol, Istanbul Aydın and Yıldız Technical universities. It is seen that 16 (26%) of education faculties have opened undergraduate courses related to STEM education to date. Universities that have opened undergraduate courses on STEM education within the Faculty of Education Afyon Kocatepe, Bahçeşehir, Bayburt, Boğaziçi, Aegean, Istanbul, Istanbul Medipol, Istanbul Aydın, Kocaeli, Maltepe, Muğla Sıtkı Koçman, Muş Alparslan, METU, TED, Yeditepe and Yıldız Teknik are universities. To give an example of these courses: Boğaziçi University "Special Topics: Current Perspectives in STEM Education" and "Special Topics: Research on Teaching and Teachers' Development in STEM Education", Ege University "STEM Education with Activities" and "STEM Activities for Teacher Candidates" courses and Muş Alparslan University opened the

courses named "STEM Education from Past to Present". It stated that in addition to the undergraduate course of Bahçeşehir University, the Department of Educational Technology also offers graduate and doctorate courses. It has been reported that STEM education is given within other courses in education faculties that do not have a separate course on STEM education at the undergraduate level, and students are encouraged to participate in activities or trainings related to STEM education.

Bartın University undergraduate courses, activities related to STEM education are carried out, and undergraduate students are directed to obtain certificates related to STEM Education.

Bilkent University has not admitted undergraduate students to the faculty for the last four years, but although there is no separate course in graduate programs, studies on STEM are carried out within the existing courses. Especially in science and mathematics education departments, integration studies related to STEM are carried out.

Celal Bayar University "Special teaching methods, instructional technologies and material design for our students who continue their undergraduate programming education in Science and Classroom Teaching in our faculty, Within the scope of science and technology laboratory applications courses, information on STEM education is provided, activities and exhibitions are organized at science festivals."

Hasan Kalyoncu University, The subject of STEM is covered in the courses related to Science and Mathematics education. In the 2017-2018 academic year, it has been stated that an undergraduate course will be opened in which STEM and Coding education will be given together.

The theoretical foundations of STEM education are given in the Black Sea Technical Undergraduate courses, and the developments in the world are conveyed to teacher candidates. At the graduate level, STEM is processed by integrating into certain units.

Although there is no direct course on STEM Education at the undergraduate level of Kastamonu University, STEM applications are made within the courses such as Science and Technology Laboratory Applications, especially in the Department of Science Education. They have prepared an elective course content related to STEM Education and stated that they are at the stage of offering a course and that they have the academic background to carry out the course.

An elective course on STEM at undergraduate level will be offered at the Faculty of Engineering-Architecture in Osmangazi University 2017-2018 fall semester. In addition, a faculty member at the Faculty of Education offered undergraduate and graduate courses on STEM Education.

STEM Education is discussed in Sakarya University Material Design and Special Teaching Methods course.

Studies on STEM are carried out in other courses at Trakya University.

There are five (8%) education faculties that have a Research Institute, STEM Center and similar institutions for STEM education: Atatürk, Bahçeşehir, Hacettepe, İstanbul Aydın and METU education faculties. It has been reported that 13 (21%) education faculties, including Artvin Çoruh, Bahçeşehir, Boğaziçi, Ege, Hacettepe, İstanbul, İstanbul Aydın, Kocaeli, Maltepe, Marmara, Muğla Sıtkı Koçman, Muş Alparslan and Yüzüncü Yıl universities, have established laboratories for STEM education.

Balıkesir University is on the agenda of establishing a STEM laboratory for each school within the scope of the "Balıkesir Quality Development and Monitoring in Education" (BENGİ) project. In another project, it is aimed to establish 19 STEM Education Centers in Balıkesir, 18 districts and 1 center. ("STEM Protocol Signed," 2017).

Erciyes and Gaziosmanpaşa University Education Faculties stated that they are carrying out project studies on establishing laboratories. Erciyes University Education Faculties will be established.

It also plans to provide in-service training to teachers working in the Ministry of National Education in laboratories. Marmara University Faculty of Education reported that one of the outputs was the establishment of a STEM laboratory. Mersin University Faculty of Education, Mersin Metropolitan Municipality and Mersin Provincial Directorate of National Education made a project proposal to Çukurova Development Agency in order to establish a STEM Center.Yeditepe University Education Faculty STEM laboratory is in the process of opening, and Yıldız Technical University Education Faculty stated that they are working on establishing a STEM laboratory. Considering the education faculties of the universities in our country, STEM research institute, STEM center and It is seen that the number of STEM laboratories is quite low. There are eight (13%) education faculties carrying out an EU project on STEM education, and 12 (20%) education faculties carrying out a TUBITAK project. Universities that only have faculties of education that carry out EU projects, Bahçeşehir, Boğaziçi, Dokuz Eylül, Hacettepe, ODTÜ, Osmangazi, Yıldız Teknik and Yüzüncü Yıl, faculties of education that carry out only TÜBİTAK projects Aksaray, Artvin Çoruh, Bilkent, Boğaziçi, Çukurova, Ege, Erciyes, Hacettepe He is at the universities of İstanbul Kültür, Muğla Sıtkı Koçman, METU and Osmangazi. The faculties of education that carry out both EU and TUBITAK projects related to STEM education are in Boğaziçi, Hacettepe, METU and Osmangazi universities. When we examine the examples, it is seen that Hacettepe University actively participates in the project partnerships across Europe. MASCIL, supported by the 7th Framework Program of the European Union, takes part in STEAM projects, STEM PdNET and STING, which are Erasmus+ projects, and INSTEM, which is the Comenius project, as Turkish partners. Only the education faculties of Bahçeşehir, İstanbul Aydın, and Muğla Sıtkı Koçman universities have web portals for STEM education. Hasan Kalyoncu University attempted to provide free STEM education to 100 girls by organizing "STEM Camps for Girls" in 2017. With the protocol signed by Balıkesir University with the Provincial Directorate of National Education, STEM training will be given to students and teachers by

faculty members at the university. Within the scope of the project, it is aimed to establish 19 STEM Training Centers, 18 districts and 1 centre. ("STEM Protocol Signed," 2017). Education faculties not only provide STEM training for students, but also STEM training for teachers in the field. Balıkesir University provided STEM training to 50 teachers whose branches are mathematics, science and technology, technology design, classroom teacher, information technologies, physics, chemistry and biology, with the project "Alternative Approach in Education: STEM" within the scope of 2016 Technical Assistance Program of EF Southern Marmara Development Agency ("An Alternative Approach to Education: STEM Project Certificate Ceremony," 2017). In cooperation with Gaziosmanpaşa University Faculty of Education and Tokat Provincial Directorate of National Education, STEM training is given to teachers within the scope of STEM Project Basic Level Trainings (Tokat STEM Project Basic Level Trainings, 2017). With the TUBITAK project "Problem-Based STEM Education for Science Teachers" carried out by Osmangazi University Faculty of Education, 28 teachers were given STEM training for nine days by academicians who are experts in their fields. With the cooperation of Osmangazi University Faculty of Education and Eskişehir Seyitgazi District National Education Directorate, classroom, Science and Mathematics teachers in the district were trained within the scope of four-month professional development with the STEM project, and classroom practices were followed at the end of the project. In addition, in collaboration with a Science High School, its academics visited the school every week and provided project consultancy to 9th grade students on preparing STEM projects. "According to PwC (PricewaterhouseCoopers) analysis, approximately 3.5 million of the 34 million total employment in Turkey for 2023 will be STEM employment, the STEM employment requirement will approach 1 million in the 2016-2023 period, and this need is approximately 31% based on undergraduate and graduate graduates. It is predicted that there will be a deficit in value." (PwCTürkiye ve TÜSİAD, 2017). Considering the ratio of STEM graduates to total graduates,

Turkey ranks ahead of Brazil, shows similarities with the USA and Austria, and falls behind OECD countries such as Mexico, United Kingdom, Israel, Poland and Denmark. (PwCTürkiye ve TÜSİAD, 2017). When we look at the years 2013-2016 in Turkey, students who graduated from STEM fields of universities constitute 17% of all graduates (PwCTürkiye and TÜSİAD, 2017).

Reference: Gökben A.G ve Çolakoğlu M.H. (2017, October)

4.9. Possibilities and recommendations for the integration of STEM fields into the secondary school curriculum

-In order to better understand the plant development, instead of the agriculture lessons that used to be applied especially in village primary schools but are no longer seen today, exemplary classical greenhouse and soilless agriculture practices are implemented in educational institutions, and volunteer groups, which will be formed from willing students, carry out planting-maintenance-harvest activities of plants in these application gardens all year long. In order to achieve better efficiency, students can develop their own greenhouse or soilless farming models, and prepare a report explaining which features of the environments they use should be improved and why.

- Volunteer groups, which will be formed from willing students, can be ensured to adopt stray animals such as cats, dogs or poultry such as chickens, ducks, pigeons to provide care in the shelters to be prepared in the school environment so that they can interact with animals, and their development can be followed by giving them the responsibility of caring. It may be requested to develop software that will control robotic systems or ready systems for the control of feed and water of animals.

-If the distribution maps of plant and animal species in the same class, team or family can be digitized and gamified, it can be useful for students to develop environmental awareness.

- By transferring the images of plants and animals in different ecosystems to digital media, by enabling students to experience environments that cannot be accessed by virtual reality or augmented reality applications, their ecological knowledge can be increased by enabling them to see and recognize living things in their own environment, thus increasing the awareness of protecting living things.

-After enabling the students to research which solutions they use to overcome the difficulties faced by living things in extreme environments, how and for what purpose they can be used in our daily lives from the solutions they find against problems such as low temperature, high temperature, high altitude, high pressure, air conditioning, air circulation, water flow.

4.10. Needs of organisations/ entities in Türkiye in the field of STEM education with regard to the adequate competencies of teachers in distance teaching/ learning

Science and mathematics teachers should receive effective and well-organized face-to-face training on STEM during the seminar period. Thanks to the cooperation between primary and secondary education institutions and education faculties, certificate trainings can be organized and the certificates obtained can be effective in the careers of teachers.

- Since many science teachers do not have enough knowledge about STEM and are not fully equipped about different education methods, they explain the curriculum subjects in the usual way and with an exam focus. Teachers should be encouraged to go beyond their habits and do activities in the field of STEM education.

School administrators should encourage teachers and provide coordination if necessary, in order to ensure the cooperation between teachers of different groups, which is necessary for providing STEM education in schools.

-For STEM education, it should be provided by educational institutions to switch to laboratory or workshop order instead of classroom order in schools and to equip classrooms accordingly.

4.11. National strategies and current national curriculum in Türkiye with regard to STEM education concerning digital education readines (using SWOT analysis)

Basic Law of National Education

Turkey, in contrast to other European countries, has a young population. The aims and principles of Turkish National Education defined by the Basic Law of National Education are to bring up individuals who physically, mentally, morally, spiritually and emotionally have a moderate and healthy personality and mentality, independent and scientific thinking power, a wide world view; who respect human rights, appreciate enterprise and individuality; who feel responsibility towards the society; and who are constructive, creative and productive and to prepare individuals for life by ensuring that they have professions which will make them happy and contribute to the welfare of the society through equipping them with the necessary knowledge, skills, attitude and habit of working cooperatively in line with their own interests, talents and abilities.

The basic principles of Turkish National Education include:

- generality and equality (educational institutions are open to all regardless of race, sex, or religion);
- meeting the needs of the individual and society;
- orientation (individuals are directed towards programmes or schools depending on their interests, talents, and abilities);
- ensuring that everybody enjoys the right to basic education;
- providing equal opportunities;
- continuity (it is essential that the general and vocational education of individuals lasts for a lifetime);
- conformity with Atatürk's reforms and principles, and Atatürk's Nationalism;
- democracy education, secularism;

• the scientific approach;
• planning;
• co-education;
• school-family co-operation;
• education everywhere.

Digital Transformation and Readiness in Education; It is not just to design a lesson, but also to design a future. In parallel with the developing technology, there is a rapid digital change from the industrial society to the information society. In our country, students have adapted to digital transformation in the education system, perhaps faster than educators.

"We must understand that the essence of education is the close relationship between a knowledgeable, caring adult and a secure, motivated child." Various kinds of digital inequalities still prevail in society. And this is affecting the younger generation and their digital future. They are the elements that need to keep up with digitalization in the process that gives education and training, which is the most basic building block of society. In order to keep up with this transformation in education, the Ministry of National Education has created the EBA platform, which is open to the use of teaching and learners. It contains many digital data in its content repository.

All education systems or schools have different problems. However, the factor that distinguishes successful systems and schools is that they can easily adapt to current conditions. The way we teach and learn has reached a turning point that will occur once in a thousand years. The Internet has broken all boundaries in terms of educational tools. We have a unique opportunity to apply these tools in new and smart ways to change education.

The most important achievement of an educational environment organized according to the STEM approach is to produce an original product in line with theoretical knowledge and 21st century skills. It is aimed to raise a generation that asks questions, researches, produces and can

make new inventions by providing full integration between disciplines with a supra-disciplinary approach. Arranging educational situations according to the STEM approach will greatly contribute to our students' meaningful learning and to develop their skills in transferring what they have learned to new situations. With the STEM approach, it is aimed for students to create a product by using the improvisation process cycle by imagining and designing with the achievements obtained at the end of the teaching-learning process.

It is aimed that students create a product by using the process cycle.

Turkish MINISTRY OF NATIONAL EDUCATION In the sample application plans prepared in line with the achievements in the curriculum; It is aimed that students create a product by using science, mathematics, engineering and 21st century skills. It is predicted that the knowledge and skills obtained as a result of such a teaching process will be more permanent.

with 21st century skills; Able to use their mother tongue effectively, have high-level skills in using English, (This process will accelerate when taught using the CLIL method.) Has a command of a second foreign language (Preferably German - Engineering Language) Learned mathematics, the language of science, supported in the field of geometry from kindergarten with mind games, Transfer Advanced skills, Technology literate, Developed three-dimensional thinking skills, Designing and producing (using 3d, wood and robotics workshops when necessary.) Developed sense of rhythm (preferably using Orff-Body percussion), Algorithm-preparing, coding, information-operational thinking skills high level, Sensitive to the environment, the world he lives in and the universe, Designs his own future, Has developed awareness of art and sports, Can work in teams, proposes solutions, produces solutions, has high communication skills, is a leader in his field, Seeing that there is power in civil initiative; In short, raising STEM literate individuals is the basic approach.

It has been started to be applied in the Curriculum at the level of the upper classes from the 5th grades. Curriculum studies for the lower classes continue.

SWOT ANALYSIS

STRENGHTS	WEAKNESSES
1. much more freedom and independence for each teacher in creating their curricula. Teachers are free to choose content, select materials and use as many diverse methods as they can think of. 2. students are also supposed to actively participate in decision making process regarding the content selection and thus create the education more interesting and appropriate for their future. 3. reform leaves many options for implementing many topics which had not been compulsory so far and shape it according to teacher's interest and student's affinities. This provides a better situation to introduce DIGITAL	1. still too many compulsory subjects. Students are still going to be overloaded with contents of 15 different subject which will make the education too heavy. Even if they have interests in STEM education and related topics the amount of compulsory content will make it very difficult for them to cope with it in a proper manner. 2. digitalization of learning. According to some experts, using tablets and laptops as main educational tool can cause less writing competences among students. Children use too much gadgets anyway, and if we force them to use them in schools we must be aware of the possibility that students won't be able to perform some basic writing skills

STEM LABS as a new curriculum content which can now be dealt with in various modules 4. different types of evaluation. The reform emphasizes the importance of formative evaluation, self-evaluation of students and peer evaluation rather than the summative evaluation which was the most promoted type so far 5. more use of digital tools which is compatible with student's interests and capabilities 6. strong backing from school district, principal and teachers. In many places the local authorities are backing the schools. 7. talented and professional teachers. A solid body of teachers with vocation, willing to perform and to innovate in teaching; The majority of the teachers are	3. some teachers who are not used on using IT tools can have difficulties in preparing lessons and meet the main reform objectives 4. parents of school children may not see the value of school curriculum Standards set by the district or ministry require more in classroom instruction in order for the teachers to be able to cover all the new requirements

well qualified (in the cities); 8. enough funding for equipment, supplies 9. learning on demand. The interest in the development of extra- curricular opportunities, like the Erasmus+ programme 10. no time and location constraints	
OPPORTUNITIES	**THREATS**
1. students gain more useful knowledge and competences. New curriculum is created primary to remove the accent from traditional learning facts and reproducing content to encouraging students on solving problems and developing different thinking skills. 2. by acquiring this values students are going to be more competitive on labour market in EU. 3. students will be more aware of their affinities and thus choose	1. different approach can cause dissatisfaction among more traditional families and it could be difficult to explain the advantages of such approach to some parents 2. not all students are from families that could afford costs of the modern learning process. Digitalization often means that students have access to internet and computers at any time but this is not the case in practice 3. great number of school cannot provide adequate working conditions, especially in rural parts

the right university and become a successful student 4. by introducing students in decision making process they can choose content which is more suitable with their interest. In this way students can maximize their potentials and become experts in fields of their interest 5. some other schools want to learn from us- chance to educate others 6. opportunities for individual and collaborative learning 7. 3. organizational and individual flexibility	of Türkiye.

4.12. National strategies in the field of education, current national curriculum, and fields that (in)directly cover STEM education regarding teaching standards, innovative pedagogies and didactic materials used in cross-curricular investigation of digital education

National Strategies; Healthy and happy individuals who have developed thinking, understanding, research and problem-solving skills, are conscious of national culture and democracy, are open to communication and sharing, have high artistic sensitivity, self-confidence, self-respect, awareness of rights, justice and responsibility, and make learning a lifestyle. Strategic targets were determined in the form of providing an environment and opportunity for his education and implementation studies have been started for a long time.An education system that raises healthy and happy individuals who are ready for life.It will be ensured that all our students gain knowledge, skills, attitudes and behaviors in line with the common values of our civilization and humanity and the requirements of the age. Curricula will be restructured as holistic, flexible and modular structures associated with skill sets at all levels. An effective measurement and evaluation system will be established to determine, monitor and support the competencies of our students at all levels in all fields and education levels. A skill-based foreign language proficiency system will be introduced that takes into account the needs of students according to their age, school type and program. With digital content that supports learning processes and skill-supported transformation, it will be ensured that our students and teachers living all over our country will have equal learning and teaching opportunities and that learning will go beyond the classroom walls. Efforts to establish an ecosystem for the development of digital content and skills continue and are coming to an end. Content was developed for the development of digital skills and teacher training was carried out in this context. Keeping up with the modern-minded self-innovative era, teachers are now looking for ways to offer a more personalized education. In the future, learning will be more individualized

and education will be social. As teachers rethink their relationship with students, curriculum and pedagogy in the 21st century, they will create innovative change in the education system and encourage children to thrive in a dynamic and rapidly evolving world. Student Achievements in Education; He will reach the information himself, learn to use it and be sharing. In education, classrooms will be harmonized with real-world working life and social environments that encourage interaction and interdisciplinary problem solving. A significant progress has been made as a country in this regard, the Fatih in Education project and EBA learning contents have been developed within the ministry. (The Pandemic epidemic in the world, in the distance education process that entered our lives, the MINISTRY OF NATIONAL EDUCATION OF THE REPUBLIC OF TURKEY has successfully accelerated and managed the process at a speed that can be considered as an example in the world.

Regarding the didactic materials, the resources available in the education system for STEM education are insufficient when spread out. However, the reasons for this inadequacy are the inadequacy of teacher training for STEM education, the fact that the students in the country's education system are focused on continuous assessment and evaluation exams, and the integration into the system is slow because the perspectives of teachers, students, parents, school management are exam-oriented.

4.13. Detailed needs of the organisations/ entities/institutions/schools in Türkiye in the field of STEM education with regard to the digital contents into the school curriculum in full compliance with the distance learning and teaching

The STEM Education of the Future should harness technology in ways that provide equitable access to all learners and ensure that all learners thrive. Skillful instruction aided by technological advances can overcome structural barriers such as cost, distance, opportunity,

socioeconomic background, or prior STEM preparation, and allow all STEM learners to overcome stereotypes and biases with the support of their learning communities.

Well-prepared educators and advisors will use evidence-based methods, pedagogies and technologies that are informed by research on how people learn in different contexts and across their lifespans. Wherever appropriate, all new technologies, including those powered by artificial intelligence, will be used in formal and informal settings in tailored ways to ensure learners acquire competencies and STEM knowledge.

In this equitable, learner-centered environment, all learning pathways should be aligned to learners' interests and include proven, experiential activities in both physical and digital ways (for example, virtual labs and online classes). Connections to relevant, real-life problems, including those in students' communities, will be what drive STEM learning. Teachers should focus on providing knowledge and experiences, such as problem solving, ethics, and decision making, that will be needed in future work contexts and jobs. These connections to real experiences will demonstrate the tangible benefits of STEM education and empower learners to own their education and become the agents of their own futures.

The STEM Education of the Future should enable learners to participate effectively in the STEM enterprise of today, and tomorrow. In a future where STEM knowledge and technology rapidly evolve, STEM learning will not merely be about mastering a stable knowledge base. Instead, learners must be skilled at lifelong learning and adapt with ease to the changing world. From reflection to metacognition to thinking in convergent, dynamic, and computational ways about complex problems, lifelong learners will need to adapt to tomorrow's challenges, and contribute to the nation's health, safety, and success in the future.

We must ensure that the appropriate technological innovations make it into learning spaces, whether face-to-face classrooms or not, guided by educators who understand how modern

technology can affect learning, and how to use technology to enhance context and enrich learning experiences for students. We need to understand how virtual distance learning environments affect cognition and learning. Learners at all levels are not always located in the same physical space, and this trend is only increasing. Virtual and distance learning present new opportunities and new challenges. Research is needed to build a deeper understanding of the possibilities of virtual and hybrid distance learning environments, from how they affect the development of skills and abilities, to the pedagogies and curriculum that work best.

• Research priorities must include exploring how new educational technological infrastructures affect student outcomes, as well as their impact on structural factors such as cost, access to quality education, faculty retention, and growth of the STEM research enterprise.

• Research needs to accelerate development, testing, and understanding of technologies that facilitate and reward remote experiential learning, such as learning that traditionally happens in laboratories and field work.

5. Türkiye

5.1. Pamukkale Üniversitesi

Pamukkale University is a state university which was founded in 1992 in Denizli. Today with its 16 faculties, 6 institutes, 3 higher education schools and 15 vocational higher education schools, Pamukkale University is training, modern, knowledgeable, creative and enterprising young brains, who Turkey and the world need, in various fields such as medicine, engineering, economic sciences, science, social sciences, fine arts, educational sciences and technical education. Despite its short history, with its 60 000 students and 5 000 employees 1500 of whom are dynamic, open-minded and challenging academics; Pamukkale University has formed a modern education and instruction and service atmosphere. The university gives great importance to international student instructor exchange and international partnerships and has signed hundreds bilateral agreements with universities all around the world and more than sixty general cooperation agreements with Europe' s and world' s leading universities. Pamukkale University has completed successfully more than thirty Socrates and LLP programme projects (including Leonardo Da Vinci projects) and four Youth projects. Some projects from LLP program are still ongoing as well as new KA1 and KA2 projects from Erasmus+. Teacher education in Turkey. The theoretical as well as applied courses that the Faculty offers enable prospective teachers to become professionals who are constantly in touch with recent scientific and technological developments and who have the willingness and capacity to apply these developments to their own teaching activities. The Faculty of Education also cooperates with the Graduate School of Social Sciences and the Graduate School of Natural and Applied Sciences to offer graduate programs which train students as prospective researchers and academics. In addition, the Faculty of Education is engaged in various research and consultation activities in relation to education, and for this purpose it cooperates with the Ministry of Education and with some private educational institutions. some projects that University of Crete has recently participated are the following:

Let's STEM it: KA201 - Strategic Partnerships for school education FormId KA201-90842873 The ''LET'S STEM IT'' partnership has been conceived against the background of the current crisis and the lack of growth and youth's unemployment that have been upsetting strongly Europe's society in the last 5 years. Education is therefore called to respond to the urgent need of highly skilled engineers and technologists and labor supply must match demand as recognizsed in the Flagship initiative "An Agenda for new skills and jobs" in the EUROPE 2020 strategy of the EC. The General objective of the LET'S STEM IT project is to guide increasing Europeans' interest and skills in STEM and to provide the schools with the necessary tools in order to engage their students, teachers and other actors, in related activities. The project aims to develop teachers' and educators' competences - especially integrated STEM (science, technology, engineering, mathematics) teaching skills, based on collaborative problemsolving (CPS) - sharing experiences among countries involved in the project (the project was compatible with PISA 2016 aims to evaluate students' performance in mathematics, science and financial literacy; performance in problem-solving and reading).

Specific Objectives of the project:

-Offer teachers collaboration in creating innovative STEM school curricula

-Contribute to developing and implementing innovative STEM education in order to enhance the quality of science teaching and learning

–to develop teachers' and educators' integrated teaching skills, based on collaborative STEM education.

-Develop a student-centered approach to STEM education, facilitating inquiry-based teaching, collaboration and active learning.

–To explore new forms of teaching, learning and assessment of students achievements

–To guide teachers and educators, how to motivate children and inspire their passion for discovery and learning

–To share experience of good practice on increasing students' interest in STEM and technical creativity; developing students' skills of logical and critical thinking

5.2. Previous experience with STEM education - projects, workshops

We own a STEM research and application center. The aim of this center is to provide educational support in all areas where the university teaches and conducts research, in cooperation with academic programs, organizes training programs, carries out research and development activities, provides scientific support to projects, and in this way, the University cooperates with national and international public institutions and private sector organizations. contributes to the development of cooperation.It provides STEM education to all teachers working in the National Education and contributes to teacher education in many national and international projects.

The activities of the center are:

a) Training of teachers, trainers and education administrators from pre-school to postgraduate level in the areas that the center focuses on, and Organizing events/programs for development.

b) Training programs for the public, private sector and international organizations and individuals in the areas they need, in line with the objectives of the Center.plan.

c) Develop massive open online courses for science, mathematics, technology and engineering education.

d) To carry out product development studies and obtain patents for science, mathematics, technology and engineering education.

e) Developing projects and programs to provide quality education opportunities for disadvantaged students.

f) To support excellence in science, mathematics, technology and engineering education and to share national and international good practices.to ensure.

g) To make all kinds of education, research, examination and publications that fall within the scope of the center, to publish periodicals and to support such studies.to ensure.

h) In researches and examinations on the subjects related to the activities of the Center, directly or indirectly, at the national and international level. To be present, to carry out project and training studies and to evaluate and meet future requests in this direction.

i) To organize scientific meetings such as national and international seminars, conferences and congresses related to the activity areas of the Center and to participate in these meetings.

The final focus of STEM Education Center is evaluation and assessment. This will include research about how best to evaluate STEM programs and how best to assess understanding of STEM, which includes curriculum development. Existing evaluation and assessment techniques need to be refined and more carefully aligned with the actual purpose they are purported to serve. The most appropriate statistical, interpretive and measurement techniques and how these approaches can be optimized to provide useful information to decision makers needs to be determined. Furthermore, careful assessment of student learning and incorporation of these measures into evaluations of STEM programs, such as instructor preparation, is critical to improving STEM education and to improving STEM assessment and evaluation.

5.3. Previous experience with STEM education - in everyday education

In Pamukkale University Faculty of Engineering curriculum STEM like activities, courses and their content is summarized below.

In thermal and mechanical design course we apply design based STEM like approach as follows:

Almost all design projects start with one or a few sentences of a client's need. Starting from here, a systematic way and method should be applied in order to produce a tangible product.

The process steps that make up the engineering design are interrelated at each stage of the project group requires active engagement and critical thinking. Starting from the draft to the usage phase

These process steps leading to decommissioning are life cycle design .

It can be collected in five basic steps as follows:

1.) Understanding and formulating the design problem

2.) Concept Development and Evaluation

3.) Detailed design

4.) Project Engineering

5.) Service application

These five steps include science, technology, education and mathematics in an integrated way.

In senior project and project management courses again we apply design based STEM like approach by my students in groups of 3 or 4 from different departments. So students from different departments teach each other according to their professions. To achieve the final goal of the project STEM like approach integrated with computer skills are used.

In addition to STEM center activities, innovative STEM applications are focused on in University courses. Examples of STEM integration lesson plans are made with teachers and teacher candidates. Science fairs are held where the products produced at the end of these activities are exhibited. Learning environments where students can experience real-life situations are provided with information technology supported studies.

5.4. Participation in project Innovative Schools Teaching&Learning in DIGITAL STEM LABS

Experimental design for certain learning objectives for certain age groups in laboratories is a subject that requires expertise. Bringing the experiments in question to the digital environment and ensuring that they serve learning objectives requires the coordinated work of people from different disciplines. Within the scope of this project the engineering faculty will develop digital stem applications in coordination with the education faculty for this purpose.

The STEM applications developed within the scope of the project will be modeled in two-dimensional software in the C sharp (C#) programming language developed by Microsoft, and the developed software will be able to run as a windows application by installing the relevant setup file in computer and ipad environments. On the main interface (menu tab) of this software, the names of each engineering application developed within the scope of the project will appear as a button. When the user selects the application he/she wants to open and clicks on the button, the interface of the application will open. Each parameter affecting the engineering application will be selected by the user and their values will be entered into the software. Depending on the parameters entered and selected by the user, the software will visually display the results by performing the necessary mathematical operations in the engineering application. The user will be able to include each parameter affecting the engineering application, depending on his/her preference, and will be able to visually see the results of the included parameter on the screen. Besides, the numerical results of each parameter defined by the user will be displayed on the screen as a table file. In this way, the user will be able to see the result of the changes made in the application both visually and as a numerical result. According to the type of engineering application developed, if an additional parameter is required to provide a better learning to the user, these parameters can be added to the software and the software can be developed. Similar operations can be performed for each application in the main menu.

As faculty members in the engineering faculty, such STEM applications will also contribute to our engineering education. We will also benefit from this aspect. Engineering students often tends to undermine importance of mathematics and science. In reality, using scientific principles, engineers solve problems that are important to society. Engineers can achieve this goal either by improving an existing product or process, or by developing a new product or process. So what is expected from engineers:

1.) Comprehension of scientific foundations related to the subject

2.) Ability to design and analyze existing components in the application area

3.) Uncover something that did not exist before and evaluate it according to various criteria

As can be understood from the above, the natural place of the engineers is the upper right quadrant of the Pasteur Quadran and in the middle of STEM approach. That is, if engineers understand the physics of a subject and its mathematics when analyzing is practical utility and application, it will be superior for their profession.

5.5. Relevant policy frameworks in the field of valorisation and interpretation and appropriate presentation of STEM education in Türkiye

In order to increase STEM studies, many projects have been started in our country and science centers have been opened. As an example of the projects carried out in our country, the "STEM For Disadvantaged Students Especially Girls" Project of Istanbul Aydın University was implemented to increase the interest of disadvantaged students and especially girls in STEM fields. In addition, Aziz Sancar's "Girls In STEM" was launched to raise awareness of global education, science and cultural exchange among 6th grade primary school girls. In the new system, which has been implemented since the 2013-2014 academic year, it is aimed to evaluate student success in an integrated manner with the learning process, not based on instant performance. In addition, this system aims to make the role of teachers and schools more effective in the education process, to ensure the simultaneous implementation of the curriculum across the country, to increase the professional performance of the teacher and to reduce the need for out-of-school education institutions. The curriculum that includes 21st century skills should include skills such as creativity, critical thinking, communication, collaboration and problem solving. These skills are important both for interpreting the given information and for applying it at work. However, the information in the curriculum should be related to real life. The complexity of the features needed in business life also affects the character traits that should be gained to individuals. For example, individuals should be able to adapt to the multi-component business world, whose players and rules are constantly changing, and should be able to recover after negative effects and empathize. In the curriculum, it is also necessary to transfer knowledge, create experience, increase creativity and gain lifelong learning habits, etc. studies should be carried out to gain features. In order to develop a curriculum with these features, it is seen that the curriculum is updated and there is a tendency towards STEM understanding.

5.6. Relevant good practices and case studies in the field of valorisation and interpretation of STEM education in Türkiye in formal and informal education

Curriculum studies renewed in 2018 in our country ensured the integration of new fields such as coding and robotics into education. More real-life problems are included in the curriculum. Application-enabled curricula also envisage interdisciplinary work. Considering the effect of STEM studies conducted in our country on students; It should be taken into account whether these activities provide students with the desired skills and characteristics and whether the studies are suitable for the purpose.

In a study in which students' views on STEM activities were investigated, students stated that STEM activities were beneficial in many ways, they wanted to improve themselves in these areas, and that the lessons should be taught with STEM activities. In the study examining the effects of STEM activities on students' attitudes towards science process skills and science lessons, it was concluded that students' attitudes and skills improved positively with STEM activities. A STEM activity (pinwheel activity) that contributes to the development of STEM fields, engineering and science practices, science literacy, knowledge and skills related to science, positive attitudes, perceptions and values in the curriculum was examined. At the end of the research, it was concluded that such activities can provide students with the desired skills. In his research, Pekbay (2017) determined that STEM-STEM activities improved students' problem-solving skills based on daily life, and it was concluded that doing practice led to positive development in students. Students stated that STEM-STEM activities are fun, and that they learned science concepts in group work and activity.

On the other hand, students expressed negative opinions about the design parts and due to some material reasons. Despite the negative opinions of the students in the field of engineering / design, Yıldırım and Altun (2015) found that the inclusion of STEM education and engineering / design applications in the lessons improves student success. Yıldırım and Selvi (2017) found that STEM applications have a positive effect on students' academic success, motivation towards their lessons, and permanence of learning. However, it was observed that STEM practices and mastery learning had a negative effect on STEM attitudes and inquiry learning skills towards science lessons. There are studies in our country that STEM activities improve students' interest and attitude towards these fields positively (Gülhan & Şahin, 2016).

5.7. Examples of educational provision about STEM education at the secondary education level, including higher educational programs

When Turkey's TIMSS and PISA exam performances are examined, it is stated in the TUSIAD (2014) report called "The Demand and Expectations for the Workforce Educated in the Field of STEM" that STEM education should be considered as a priority in order for us to rise to higher levels and advance to more advanced levels in economic terms. In our country, it has been determined that the average employment rate of graduates from STEM education fields is 19%. When the data of ÖSYM are analyzed, it is seen that the rate of STEM graduates in Turkey is 19%. When the field contributions of the companies were examined, it was observed that there was a significant difference between those working in the field of STEM and those working in non-STEM fields, and it was emphasized that our country should have a STEM education strategy (TUSIAD, 2014).

Although there is no national general strategy for STEM education, it is seen that there are aims to strengthen STEM in Turkey in the 2015-2019 Strategic Plan. The 2011-2016 Science and Technology Development Plan prepared by TUBITAK (The Scientific and Technological Research Council of Turkey) emphasizes the activities that support STEM education of students . In the National Science and Technology Policies Strategy 2003-2023 document, the objectives related to the field of education;

"In the field of education, it develops the creativity and imagination of the individual; by observing and evaluating individual differences, each individual can develop himself at the highest level in line with his characteristics; freed from time and place constraints, created its own unique learning technologies and has the power to renew itself with its flexibility of change; learning and having a people-oriented education system".

5.8. Best practice curricular/methodological models for the integration of STEM skills in general education subjects at the lower/upper-secondary level that exist in Türkiye, practical teaching/ learning arrangement in distance education

In order to deliver STEM education to large masses equally and effectively, the opportunities of information technologies should be used in all teaching processes. The aim of the FATIH (Movement to Increase Opportunities and Improve Technology) project in Education is to create individuals equipped with 21st century skills and a production-based society (MEB, 2010). The interactive whiteboards provided to our schools within the scope of the FATIH Project, broadband internet connection, tablet computers provided to our student teachers and the Education Information Network (EBA) are information technology tools that contribute significantly to the environment that can be used for STEM education of students.

FATIH Project is carried out by the General Directorate of Innovation and Educational Technologies of our Ministry. Within the scope of the FATIH Project, interactive boards, broadband internet infrastructure and access, and a tablet computer set for teachers and students are provided to all classrooms in public schools for the effective use of IT (information technology) tools in the learning-teaching process in order to increase the quality of education and training and to ensure equality of opportunity. In addition, many electronic content is offered under the Education Information Network (EBA) to be used in the lessons.

The use of information technologies is emphasized in education programs that comply with the principles of STEM education approach. The development of students' skills of questioning, accessing information, bringing together interdisciplinary knowledge and using them to develop products, inventions and innovations can be accelerated by the use of information technologies in education. In the age of information and technology, where traditional education approaches are inadequate, the effective use of information technologies is among the skills that come to the fore in STEM education approaches, and at this point, the opportunities and opportunities offered by the FATIH project and EBA become even more important.

In addition, the need for everyone participating in STEM education processes (teachers, students, administrators, parents, etc.) to benefit equally from information technologies and to achieve equality of opportunity will be met with the FATIH Project in Education.

In summary, by using tablet computers, interactive whiteboards, broadband internet connection and EBA content suitable for STEM education provided within the scope of FATIH Project in Education;

• Facilitating STEM education based on inquiry, research, product development and invention,

• Providing an environment for students to do STEM education activities regardless of time and place,

• Supporting STEM education by using virtual laboratory materials in multimedia,

• Increasing the quality of information technologies used in the field of STEM education in our country,

• Ensuring equality of opportunity in STEM education between the children of families with low socio-economic level and those of families with high socio-economic level,

• It will be ensured that students can carry out learning activities based on inquiry, research, product development and invention outside of school by means of information technologies

5.9. Possibilities and recommendations for the integration of STEM fields into the secondary school curriculum

Bringing different disciplines together through program integration is a complex and difficult process. Program integration is not as simple a process as bringing together subjects related to closely related courses. Although there is no consensus or conceptual framework on curriculum integration, it has been said by many researchers that curriculum integration facilitates learning and has a positive effect on students' attitudes.

Science and mathematics disciplines can be integrated into different disciplines and given together. In this way, meaningful learning can be achieved by integrating science and mathematics disciplines with different disciplines. E.g; It will be seen that establishing a connection between science and mathematics disciplines and other disciplines will be beneficial, and the relationship between science and mathematics with other disciplines will facilitate learning (Yıldırım & Altun, 2015).

For example, Instructors can deliver different content in an integrated way. For example, electricity generation from wind energy is a subject of science, while calculating kinetic energy is related to equations in mathematics.

Most secondary school students are not interested in science, technology, engineering and mathematics (National Science Board [NSB], 2008). This indifference manifests itself especially in the field of engineering. The biggest factor in this is due to the fact that students do not have sufficient knowledge and content related to engineering throughout their secondary school education. On the other hand, the scarcity of qualified programs on the integration of science, technology, engineering and mathematics and the lack of knowledge of teachers about integrating the subjects into the curriculum are some of the main reasons (Rockland et al., 2010). As a result, it is necessary to integrate engineering concepts and practices into different subject areas.

5.10. Needs of organisations/ entities in Türkiye in the field of STEM education with regard to the adequate competencies of teachers in distance teaching/ learning

One of the most fundamental problems of the Turkish education system is not insisting on the educational policies put into practice and the product that will emerge as a result of the process is included in the next system without subjecting it to objective observations and evaluations. This problem should be prevented from becoming chronic. For Turkey, which is a country with a young population and open to innovation, a road map should be determined before the opportunities offered by STEM education lose their importance and necessary steps should be taken in this direction without losing time. Suggestions that can be put forward in this context can be grouped under the following headings:

Within the Universities Establishment of STEM Centers

Considering the fact that we have a serious academic knowledge in Turkey, it would be right to place universities at the center of the reform movement in the process of integrating STEM education into the country. Investments made in the last fifteen years

As a result of this, STEM centers to be established within the body of universities established in each province – in some provinces two or more – can play an effective role in the implementation of the roadmap drawn by the Ministry of National Education. In addition, the problems faced by universities

intervention taking into account local dynamics

This policy proposal gains importance when the possibilities are evaluated. The duty of STEM centers to be established within universities with this project should be to provide consultancy services to educational institutions.

Education Faculties Adapting to STEM Skills

Change in education begins in the classroom, and change in the classroom begins with the teacher. It is very important to increase the quality of education faculties and to have courses and activities that will internalize the STEM education approach in teacher candidates. Suggestions developed for education faculties to train teachers with STEM skills are as follows:

- Joint courses can be opened by establishing cooperation with Science and Literature Faculties (For example, basic physics, basic biology, basic chemistry, basic mathematics, etc.).
- Joint courses can be opened in cooperation with engineering faculties (For example, introduction to engineering, applied science, etc.).
- Teacher candidates can be encouraged to use laboratories by increasing the number of laboratories in Education Faculties.
- Pre-service teachers can prepare lesson plans suitable for STEM skills in their teaching practices (internship) and can carry out activities by focusing on STEM skills in practice.

Curriculum Making it Suitable for STEM Education

Curriculum is very important in Turkish education system. It is very rare for teachers to take initiative by breaking away from the curriculum. Despite this, STEM education, which was wanted to be integrated into our education system, did not find a response. After realizing this situation, a new Science Curriculum draft was prepared by the Ministry of National Education in 2017, and the draft of the program, which was opened to the opinions of the interested parties, was accepted with some changes in 2018. In the published program, it is emphasized that skills such as analytical thinking, decision-making, creative thinking, entrepreneurship, communication, teamwork, innovative thinking and the science, engineering and entrepreneurship applications section and all units should be processed within this framework and perspective. For It has a very important place in Turkey. It is beneficial to continue the program changes made by the Ministry of National Education by focusing on the outputs of the education.

Establishment of Science Centers and Supporting Existing

In learning processes, auxiliary mechanisms such as science centers and museums are important for putting theoretical knowledge into practice and transforming abstract concepts into concrete equivalents. In recent years, the support of the central and local government in our country, With the initiatives of TÜBİTAK, many science centers (Konya, Kocaeli, Bursa, etc.) were opened and many students were hosted.

Suggestions for increasing the quality and number of science centers are as follows:

- The number of science centers should be increased, To increase the qualifications of existing science centers necessary support should be given.

- Science centers are determined by the Ministry of National Education as content with activities in line with the curriculum should be equipped and schools should routinely centers should be visited. In this way can be seen students' abstract knowledge science practices that are embodied and turned into products.

There is a great need for interdisciplinary thinking, which STEM education basically aims at in Turkey. It would be good to raise new generations with a culture of production and creativity in order to ensure that the production policies that have emerged as a result of large investments in recent years continue to increase and to ensure continuity. In this respect, it is beneficial to support and disseminate the STEM education approach, which emphasizes the sense of curiosity in individuals and supports the transformation of the information learned in the education process into a product with original ideas.

5.11. National strategies and current national curriculum in Türkiye with regard to STEM education concerning digital education readiness (using SWOT analysis)

Although there is no direct action plan prepared by the Ministry of National Education for STEM education in our country, there are aims to strengthen STEM in the 2015-2019 Strategic Plan. It is seen that the aims of STEM overlap to a certain extent with the objectives of the Technology and Design course. It can be said that the studies carried out at the 7th and 8th grade levels within the scope of Technology and Design course are for STEM. In order to improve the results of exams such as TIMSS and PISA, STEM education should be considered as a priority in our country.

On the other hand, it has been determined that the average employment rate of graduates from STEM education fields is 19% (TUSIAD, 2014). When the data of ÖSYM are analyzed, it is seen that the rate of STEM graduates in Turkey is 19% (OSYM, 2014). When we look at the areas in which they contribute to companies, it has been observed that there is a significant difference between those working in the STEM field and those working in non-STEM fields (TUSIAD, 2014). TÜSİAD (2014) also emphasizes that STEM education is important for our country and that a STEM education strategy should be determined. In this strategy, it is necessary to plan activities to increase the number of students who will receive education in the field of STEM and to create employment in this direction. In addition, R&D investments should be supported in order to carry out innovation studies. In the field of education, with the transition to STEM education, students have a more qualified education and the 21st century. they are expected to acquire skills (problem solving, critical thinking, etc.) (TUSIAD, 2014).

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, science centers have started to be opened in various provinces by TUBITAK regarding STEM education in our country. 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).

Studies and projects related to STEM education in universities are not very common in our country (Çorlu, 2013). The studies carried out to increase STEM education skills with trainings that strengthen the integrated teaching knowledge that teachers and prospective teachers will receive within the scope of in-service training and education faculties are very insufficient. In order to switch to STEM education in our country, students and teachers in several universities STEM centers have started to be opened. Hacettepe University and Istanbul Aydın University made the first attempts in this regard.

On the other hand, the General Directorate of Innovation and Educational Technologies has been included as a national support point since 2014 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. The Scientix community is open to teachers, researchers, policymakers, families, and anyone interested in STEM education. The Scientix project continued as Scientix 2 between 2013 and 2016. from 2016 It continued as Scientix 3.

In addition to the Scientix project, one of the many projects carried out for this purpose in Europe is the eTwinning Project. A closer look at both Scientix and eTwinning reveals that these two projects have a lot in common. Both appear to be top priorities for community building and European cooperation, by empowering and encouraging teachers to take more action and apply innovative ideas and approaches in their classrooms, to carry out collaborative and interdisciplinary work.

Some of the eTwinning projects are:

- My STEM Adventure Begins (Preschool - STEM)
- Health Innovation With Stem eTwinning Project (Primary School - STEM)
- ASTRO-STEAM eTwinning Project (Middle School - STEAM)
- Nature Doesn't Produce Waste (High School - STEM)

When we look at the science curriculum implemented in Turkey since 2018, the achievements that can be accepted within the scope of STEM education are 1.85% of the academic year at the 3rd grade level, 5.56% of the academic year at the 4th grade level, and 5.56% at the 5th grade level. 4.86% of the academic year at the 6th grade level, 4.17% of the academic year at the 6th grade level, 8.3% of the academic year at the 7th grade level and 7.64% at the 8th grade level. It has been concluded that it covers the scope (Bahar et al., 2018). Raising these rates will be good for future generations. Because in order to overcome real life problems, it is necessary to approach events from different and multiple perspectives and to use the knowledge in one field by transferring it to other fields has become. Realizing this is possible through the 21st century skills that every individual should have (Bahar et al., 2018). In order to survive in the 21st century, people need skills such as "creativity", "critical thinking", "problem solving", "cooperation" (Akgündüz et al., 2015). STEM is one of the approaches that will teach individuals how to do this. Therefore, the integration of STEM into the curriculum is important and necessary.

5.12. National strategies in the field of education, current national curriculum, and fields that (in)directly cover STEM education regarding teaching standards, innovative pedagogies and didactic materials used in cross-curricular investigation of digital education

Although not under the name of STEM in the recent past in Turkey, Village Institutes are a good example of STEM work. The transition to the constructivist approach as a curriculum in 2004 can be perceived as the first concrete steps of STEM thought. Because STEM thinking based on practice can be realized with an application and learner-centered constructivist approach. Until 2016, there is no official STEM action plan prepared in Turkey. However, since 2004; STEM is addressed in some reports prepared by institutions such as TUBITAK, Ministry of Development, TUSIAD, MEB and Istanbul Aydın University. In 2016, the General Directorate of Innovation and Education Technologies of the Ministry of National Education published the "STEM Education Report", revealing what needs to be done to include STEM in the Turkish education system, and an action plan of nine items was prepared (Türk, 2019: pp. 62-63; MEB, 2016).

STEM education is seen more clearly in the Science Curriculum prepared by the Ministry of National Education in 2018. In the new curriculum of the Ministry, starting from the 4th grade, in the Science course curriculum, the goal is to help students establish the connection between engineering and science, understand the interdisciplinary interaction, and develop a worldview by making what they have learned experiential. In the same program, it is important for students to experience science and engineering practices in order to increase the scientific research and technological development capacity, socio-economic development and competitiveness of our country. Within the scope of Science, Engineering and Entrepreneurship Applications in the program, first of all, students are expected to define a daily need or problem related to the topics covered in the units. It is desired that the problem is aimed at improving the tools, objects or systems used or encountered in daily life. In addition, the problems should be handled within the scope of material, time and cost criteria. statements show that STEM is prominently included in the curriculum (MEB, 2018: p.10).

It is understood that considering STEM as an integrated content, especially in Finland, and presenting an integrative approach to science and life is more valuable for Turkey as well. Because the sciences arising from the reading of life should be transferred to future generations as a whole with life. In fact, a correct understanding of STEM can be interpreted as the realization and learning of science in life.

Insufficient Aspects of STEM Education

In the light of the information obtained, one of the most important factors behind the efficient functioning of STEM education is school. The fact that school administrators show the necessary interest in this lesson and ensure the adequacy and effective use of the materials in the school affects the course of the course in a positive way. But it cannot be said that this situation always happens. In some schools, the course may deviate from its purpose due to the lack of laboratories or materials; students may not get enough efficiency from the lesson.

Another missing point is that students have insufficient knowledge about this course. Students who see that they are not subjected to an exam in the course may be inclined to think that the information shown in the lesson is meaningless or that the information in this lesson is unimportant. In order for STEM education to become more meaningful by students, it is necessary to raise their awareness on this issue.

One of the misconceptions about the STEM course is that only simple robots or models are made in this course and it deviates from the purpose of this course and focuses only on entertainment. Just making models or waiting for robots to walk and move by writing some small codes is thought to be STEM education by some people. Although such materials that help the course are the raw material of STEM, the situation is not as simple as it seems or claimed because there are learning models such as project-based learning, learning by problem solving, learning by questioning in this educational approach, which includes many disciplines.

There is also a widespread perception that STEM consists of only robotic sets. It can only be STEM if robotics education is used for engineering, math, and most importantly science, rather than assembling parts using some kits.

5.13. Detailed needs of the organisations/ entities/institutions/schools in Türkiye in the field of STEM education with regard to the digital contents into the school curriculum in full compliance with the distance learning and teaching

Firstly, most of the teachers agree that the students' abilities on STEM subjects have a big effect on how they design and apply STEM activities. Also, the same teachers suggested that the students who have a highest academic achievement have not volunteered in STEM activities; on the contrary, the students who have a low academic achievement are at the forefront in the STEM activities. Teachers are concerned about determining how the students ask for support in order to comprehend and complete the project of STEM integration. Secondly, all of the teachers believe that some science units/subjects such as energy, force and speed are easy to use those with STEM integration. However, the other teachers, think that the science units/subjects such as biology or chemistry are not too easy. Thirdly, most of the teachers STEM integration felt uneasy because they did not have experience. They have stated that this situation is threatening the classroom management. Additionally, time, material and curriculum are the ones of biggest problems affecting the application of STEM activities.

The teachers are also worried about how they give instructions to their students in order to describe STEM activities. In general, STEM activities were complex. The students talked with their group friends about their designs, walked around the classroom to test their products or wasted time, and did not do anything that they had to do.

6. Greece

6.1. PANEPISTIMIO KRITIS (University of Crete)

The University of Crete is a multi-disciplinary, research-oriented public educational institution. It has 16 Departments in 5 Schools (Philosophy, Education, Social Sciences, Sciences & Engineering, and Medicine) as well as several affiliated institutions, including the Skinakas Observatory, the Natural History Museum, and the University General Hospital. Research and research training at all levels benefits also from the close collaboration between many of the University's research groups with the Institutes of the Foundation for Research and Technology – Hellas (FORTH) and the Institute of Marine Biology & Genetics (IMBG).

Research and research training activities at the University are organized along the lines of the Divisions within each Department. Research activity follows the classic academic model insofar as it is driven by the initiatives of scholars and scientists in developing their own curiosity-driven or practice-based projects or working in collaboration with other research groups. These collaborations mirror the increasingly multi-disciplinary and inter-disciplinary character of both basic and applied research, which is also reflected in the interdisciplinary character of many of the University's postgraduate studies programmes.

Consistent with its research orientation, the University of Crete is the first Greek University to have signed the EU Charter and the Code for the recruitment of researchers, and forms part of the EURAXESS European network for the mobility of researchers. The University fully participates in quality assurance mechanisms and is committed to meeting quality standards both for its academic and administrative structures.

Indicatively, some projects that University of Crete has recently participated are the following:

- Erasmus + : Key Action 2 Strategic Partnerships 2019 : 3D printing support service for innovative citizens 2019-1-IE02- KA203-000693

- Erasmus + : Key Action 2 Strategic Partnerships 2019: Enabling Mental Health Benefits 2019-1-UK01- KA203-062148
- Erasmus + : Key Action 2 Strategic Partnerships 2017: Bridging languages and memories to foster multiple identities: "Never leave your backpack behind!" 2017-1-EL01- KA201-036197
- Erasmus + : Key Action 2 Strategic Partnerships 2018: Promoting Social, Emotional, and Learning Skills of Students with and without Special Education Needs by Developing Teachers' Capabilities in Music, Dance and Digital Competences 2018-1-SE01- KA201-039032
- Erasmus+/K2/Capacity Building in Higher Education 2018: DECIDE 598661-EPP-1- 2018-1-ROEPPKA2-CBHE-JP
- HORIZON 2020: 2020 SIGMA- NEXUS 1943- SIGMANEXUS
- HORIZON 2020: 2020 MOVING 862739

More specifically, at the Department of Primary Education of University of Crete is located the Science Education lab which was established in 1989. The Science Education lab focuses on research about the educational use of digital technologies and the integration of the educational innovations of ICT such as data loggers, virtual & augmented reality, and educational robotics in STEM teaching. Particularly, master's degree theses, as well as bachelor theses, focus on developing teaching materials for science lessons with the use of microcomputers, robotics, and virtual reality environments. Moreover, the Science education lab gives emphasis on pre-service & in-service teacher education and also studies the influence of informal and out-of-school contexts in STEM education. Considering its educational role, the lab offers training to pre-service primary teachers both in content knowledge and teaching methodology knowledge in the domains of science, mathematics, and technology. The main educational goals of the Science Education lab are a) the integration of the educational innovations of digital technologies in science teaching at the primary school, b) cultivating inquiry and engineering skills in pre-service primary teachers, through the construction of interactive artifacts which relate to real-world STEM projects and concurrently address contemporary socioscientific issues and c) the integration of mathematics in science lessons concerning contemporary topics.

Some European projects that the Science Education Lab has participated recently are:

IRRESISTIBLE (fp7, Grant agreement no 612367, http://www.irresistible-project.eu). IRRESISTIBLE is a project on teacher training, combining formal and informal learning focused on Responsible Research and Innovation. The goal of the project is to design activities that foster the involvement of students and the public in the process of Responsible Research and Innovation (RRI). During the first phase of the project (2014-15), various modules were developed, such as Nanotechnology applications, Oceanography and climate change, Renewable energy sustainability, Climate change etc. The modules included inquiry based (IBSE) elements for students and foster the aspects of responsible research and innovation (RRI) in different ways.

IDENTITIES (ERASMUS +, KA2, 2019-1-IT02-KA203-063184, www.identitiesproject.eu). The project has been producing interdisciplinary modules for pre-service teacher education. IDENTITIES is elaborating on a specific model of teacher education and is adapting it to prepare teachers to teach both curricular and advanced STEM interdisciplinary themes.

STEM DIGITALIS (ERASMUS +, 2020-1-EL01-KA226-HE-094691, http://stemdigitalis-project.eu). The aim of the STEM-DIGITALIS project is to develop blended and distance learning environments for teaching advanced STEM topics (e.g. climate change, plastic waste, renewable energy, etc.) for prospective primary and secondary science teachers education.

6.2. Previous experience with STEM education - projects, workshops

The Science Teaching Laboratory of the University of Crete has participated in two other Erasmus+ KA2 projects which are explicitly related to STEM Education. In particular, since 2019, the University of Crete participates in the Erasmus+ KA2 project "IDENTITIES: Enlightening Interdisciplinarity in STEM for Teaching" (www.identitiesproject.eu), which is a strategic partnership of 5 universities from 4 EU countries. The aim of the project is to design and develop teaching modules in order to foster interdisciplinary thinking and skills to preservice secondary teachers from the STEM disciplines in order to innovate teacher education and to prepare a new generation of teachers able to cope with contemporary societal challenges. The project has two foci on interdisciplinary topics: a) advanced STEM topics which are intrinsically interdisciplinary (Climate Change, Nanotechnology, modelling Coronavirus evolution) and b) curricular topics concerning "border problems" between Mathematics-Physics and between Mathematics-Computer Science (such as Relativity & non-Euclidean Geometries, Cryptography, Parabola & Parabolic Motion) in order to make traditional curricular topics more engaging, relevant and meaningful. In specific, the University of Crete has participated in developing a STEM module on Nanotechnology, as well as in the development of an interdisciplinary teaching module related to Relativity and the historical development of non-Euclidean Geometries.

In addition, since June 2021, the University of Crete participates in the Erasmus+ KA2 project "STEM Digital Distance Learning in University Teaching", which is a strategic partnership between 5 universities from 5 EU countries. The aim of the project is to develop the digital education readiness by designing and developing STEM digital scenarios for tertiary education as well as teaching and learning strategies that promote the meaningful use of digital technologies for teaching STEM topics in blended and distance learning environments. The project also aims to develop an open-access educational platform that the developed digital material shall be shared online across diverse contexts.

The Science Teaching Laboratory of the University of Crete has also organised and participated in an international summer school in terms of the project IDENTITIES described above. Student teachers (n=26) from the participating universities experienced training in interdisciplinary STEM topics, such as Nanotechnology, Cryptography, modelling Coronavirus evolution and Parabola and Parabolic motion. The summer school was implemented in online mode due to the pandemic restrictions. Hence, student teachers experienced digital STEM activities, reflected on epistemological issues related to STEM disciplines and the integration of the disciplines, as well as the boundaries and boundary crossing mechanisms of the STEM disciplines. Student teachers also engaged in linguistic activities in order to foster interdisciplinary thinking from several different lenses.

Moreover, the Science Teaching Laboratory has organised several STEM trainings workshops for in-service teachers during the academic years 2018/19 and 2019/20. Participating in-service teachers attended informative lectures about theoretical principles of STEM education as well as lectures concerning contemporary STEM topics, such as Nanoscience-Nanotechnology. Subsequently, they also experienced laboratory settings by using digital technologies such as datalogging systems, as well as artefacts and exhibits that make use of digital tools. Also, they were called upon to design and develop their own STEM teaching material (STEM artefacts and STEM lesson plans).

Regarding informal learning environments, the Science Teaching Laboratory of the University of Crete in cooperation with the local authorities has created the science museum "Science in the City". In this informal learning center, organised educational visits for school students are been organised and implemented as a result of the cooperation between the schools and the academic personnel. Visiting students experience interactive STEM activities (such as digital technology-integrated experiments, virtual reality immersive digital environments, interactive whiteboard activities) and digital technology-enhanced artefacts (such as hand-made constructs with sensors and datalogging systems and robotic constructs) with which they are given the chance to gain deep understandings of the phenomena through visualisations as well as to increase their interest for STEM.

6.3. Previous experience with STEM education - in everyday education

Regarding pre-service teacher training, the Science Teaching Laboratory of the University of Crete has offered several STEM-related courses to undergraduate students of the STEM academic departments. In particular, a course named "STEM Education" has been offered during the academic year 2020/21 as part of the interdisciplinary programme for future secondary teachers of the Faculty of Sciences and Engineering of the University of Crete. Participating students from the Mathematics, Physics, Chemistry, Biology, Computer Science, Materials Science and Applied Mathematics departments were introduced to theoretical principles of STEM Education and STEM Integration and were subsequently called upon to design and develop STEM teaching material, i.e. STEM artefacts and related STEM lesson plans for distance learning modalities. Student teachers also reflect on STEM integration and are engaged in epistemological discussions regarding the nature of the STEM disciplines and the arising interconnections between them.

The same course was also offered to undergraduate students of the Primary Education of the University of Crete during the academic years 2018/19 and 2020/21, as part of their training for STEM domains. Participating students were called upon to design and develop STEM lesson plans and STEM artefacts either in the form of physical constructs or in digital form in distance learning modalities for teaching primary school students.

Furthermore, students of the Primary Education Department are given the chance to participate as practitioners to STEM projects during their last year of studies. In particular, students who apply for a bachelor thesis under the supervision of the prof. of Science Education D. Stavrou are involved in designing and developing STEM series of activities (such as experiments, artefacts, digital materials, serious games etc). Their activities aim to engage students in interdisciplinary problem-solving as well as STEM content knowledge and skills development. Subsequently, student teachers implement the developed STEM teaching material for teaching school students during their teaching practice programmes.

Furthermore, primary student teachers also experience interdisciplinarity during the implementation of courses that engage socioscientific issues, i.e. authentic, real-world, science-based controversial issues that require students to develop both scientific content knowledge as well as moral and ethical reasoning. In specific, student teachers are called upon to design and develop exhibits and artefacts, such as interactive games, posters, constructs that promote interdisciplinary thinking to students as a prerequisite in order to address contemporary societal challenges.

Primary student teachers as well as Kindergarten student teachers engage in STEM activities through educational robotic platforms (such as Lego Mindstorms, Lego WeDo) during the undergraduate course "Educational Robotics" of the Department of Primary Education and the Department of Preschool Education. During the course, student teachers design and develop digital artefacts with the use of robotics and moreover, are called upon to integrate knowledge and skills from Science, Mathematics, Engineering and Technology. In addition, student teachers use the designed artefacts for teaching school students during organised educational school visits at the university lab.

Furthermore, undergraduate students also experience interdisciplinarity in an implicit or explicit way in a series of other undergraduate courses, such as "Quantum Structure of Matter", "Condensed Matter Physics" in the Physics department, in which students engage in interdisciplinary connections between Physics, Chemistry and Mathematics as well as in the courses "Analytic Biochemistry" and "Food Chemistry" in the Chemistry department, in which students engage in interdisciplinary connections between Chemistry, Mathematics and Biology.

Undergraduate students also experience integration of Technology, Science and Mathematics during their laboratory practices. For example, during the course "Experimental Physics and Chemistry" or the "Design, Development and Evaluation of Teaching Material" in the Primary Education Department, student teachers are called upon to purposefully integrate and make meaningful use of Digital Technologies and explicitly reflect on them when engaging with experiments or when they design and develop new digital technology-rich experiments.

6.4. Participation in project Innovative Schools Teaching&Learning in DIGITAL STEM LABS

The research that was carried out for the purposes of the intellectual output 1 revealed that in Greece the implementation of STEM approaches in formal education are really rare (for more details see the answers below). Usually, STEM approaches take place as extracurricular activities in schools or in informal learning environments. Thus, we expect that UoC participation in the project will enrich STEM activities in real classrooms, inform national policy makers about European policy regarding STEM education and digital readiness and finally will improve existing teacher training programs. In more detail:

- The pandemic and its impact on all levels of education with the nearly compulsory conversion of all offered courses in an online form, has brought forward the need for both educators and learners to develop digital skills and for courses to be enriched with digital contents. In particular, universities that prepare teachers had to convert their courses to blended/distance learning, but the university educators and student - teachers were not properly equipped with the necessary methodology for blended/distance education. Additional difficulties arose in the teaching of STEM courses that require students' hands-on interaction to develop not only knowledge but also skills. Therefore, through UoC participation in the project we foresee developing such digital materials and methodologies that will be used in case of blended / distance learning and improve the quality of the already available courses.
- Moreover, the development of digital contents and the use of digital tools in STEM education will give our research team the opportunity to investigate how such digital materials and tools can be used in STEM education, to assess their integration in STEM courses and therefore to provide the STEM education community with the necessary feedback and guidelines for an effective integration.

- Furthermore, the participation of in-service teachers will give our research team the necessary feedback on the way teachers employ digital contents in STEM courses, on their expectations, needs and difficulties. Such feedback will support the improvement of our pre – service teacher education programs as well as the professional development programs of in service teachers.
- Additionally, the community of practice among researchers and in service teachers from all around Europe will make our research team and institution more familiar with diverse European educational and cultural contexts and will increase the transferability of the digital materials and methodologies that will be developed.

6.5. Relevant policy frameworks in the field of valorisation and interpretation and appropriate presentation of STEM education in Greece

In recent years, STEM education has become a new educational approach for 21st century students. In the USA was particularly emphasized, with the ultimate aim of covering the labor force needed for globalization. At a more general and global level, STEM education is considered to equip students with the appropriate innovative knowledge in science, technology and mathematics thus providing them with the most chances of finding work.

However, according to the results of a competition of different countries that was held in 2018 and concerned the evaluation of students' knowledge in both the Greek language and in Mathematics and Science, the publications from the Institute of Political Education make clear that Greece is not moving at the same pace as other countries. More specifically, Greek students scored lower than average in the Natural Sciences and Mathematics.

Nevertheless, in recent years, continuous efforts have been made in order for more and more students and teachers to get in touch with STEM education. This is because not only this approach can be integrated into schools, but also its effective teaching by teachers, who must respond to current students by providing them with higher education.

It is worth noting that STEM teaching nowadays and consequently in our country, has greatly improved compared to previous years, but retains some of the initial limitations such as lack of adequate knowledge of teachers and the lack of appropriate logistics infrastructure. Thus, all STEM teams are founded, mainly in the private sector in education, they follow related actions in the public school, even in the children of the Kindergarten, while at the same time STEM competitions are organized such as the First Lego League, WRO, STEM Stars Greece. In addition, it is worth noting that in addition to private companies that have invested in STEM education, many Greek Universities, including the University of Crete, claim a dynamic presence in the field of STEM through various academic courses and programs.

However, our country participates in many European Programs such as Scientix which is supported by the European Schoolnet and funded by the Horizon 2020 program of the European Union. Also, through the eTwinning and eTwinning + platform, the Safer eTwinning STEM/ steam Projects program is carried out, which promotes the cooperation of countries both inside and outside European countries.

As mentioned at the beginning, the training of the executive has received increasing attention in recent years for two main reasons. Initially, to give more emphasis to these Areas but also to upgrade the teaching process. Although with a relatively long lag, Greece is slowly integrating STEM teaching into the field of education so that students learn to explore the lessons qualitatively, developing specific skills, generalizing and transferring knowledge to a real and everyday situation.

6.6. Relevant good practices and case studies in the field of valorisation and interpretation of STEM education in Greece in formal and informal education

The curriculum of primary and secondary education in Greece is not explicitly mentioned in the education of STEM. However, the government, knowing the need to integrate the STEM education in the country's schools, has tried to integrate it in other ways. Until now in Greece the closest version of STEM education can be considered the project method. This method was promoted through the course of the Flexible Zone, through the new interdisciplinary curricula of 2003 and the "New School" in 2010. The Project method is part of the "experiential / experiential learning" and is an "open type" pedagogical approach, which allows the spontaneous and organized activity of a group of students, to complete a task that students have chosen or to solve a problem.

At the present time, an effort is made by the Institute for Educational Policy to integrate STEM education through some of the ordinances that have recently been implemented. More specifically, a new ordinance called "Skills Workshops" was implemented just a year ago. This year, the operation of Skills Workshops in Kindergartens, Primary and Secondary Schools across the country is expected to begin in October. The teachers in charge of teaching the Skills Workshops are invited to design the Skills Development Programs. The design will necessarily include the implementation of the four (4) Thematic Units and may include from 20 to 28 Skills Development Programs. The four topics are: Living Better, Taking Care of the Environment, Being Interested and Acting, and Creating & Innovating. The fourth topic explicitly mentions STEM and STEAM education. Some titles of available laboratories are: "Little Meteorologists", "STE (A) M and Educational Robotics through the Water Cycle and Hydrodynamics", "Heroes of the World (STEAM Activity Lab)", "ELEFYS - Illustrated Dictionary of Physics the School "," Materials for a Sustainable Future "," STEAM Curriculum" http://iep.edu.gr/el/psifiako-apothetirio/skill-labs/1008-stem-steam. The goal has been defined based on the skills of the

21st century: life skills, soft skills and technology and science skills. Indicatively, modern skills include critical thinking, creativity, collaboration, communication, flexibility and adaptability, initiative, organizational ability, empathy and social skills, problem solving, digital and technological literacy.

In terms of non-formal education and its structures such as Science and Technology Centers and Science Museums in recent years have begun to offer many corporate activities to students. Below will give some examples of cases involving such structures. For example, Evgenidou institute offers several activities based on STEM education. An example which is offered during this time is the "Paper Plane Launcher" that is part of the Robotics Lab and where children make paper planes, evaluate how far they can go and then build launchers. They program the launcher and send the paper plane into the air. https://www.eef.edu.gr/el/nea/eksereyniste-ta-apithana-programmata-tou-kentrou-epistimis-kai-tehnologias-tou-idrymatos-eygenidou/

Another example is given by the science and technology center NOESIS. NOESIS organizes STEM workshops (Science, Technology, Engineering, Mathematics - Science, Technology, Engineering, Mathematics) for kindergarten children (4-5 years old) up to 6th grade. One of which is "Peiramatistas". The workshops of Peiramatistas complement and enrich the learning environment of the school and function either as an occasion or as the end of an educational process in the school everyday life. They include simple experiments with everyday materials, clever toys and constructions. The workshop process is participatory, collaborative and highly experiential. It concerns STEAM sciences (Science, Technology, Engineering, Art, Mathematics) and combines experiments, constructions, games. Peiramatistas science laboratories were presented as a good educational practice at the 2nd International Conference of the University of Macedonia "Reimaging schooling", Thessaloniki, September 2015. https://www.noesis.edu.gr/visitors-peiramatistas-october-2021/

Also, the center of science and technology "Science in the City" in Rethymnon which is under the auspices of the science teaching laboratory of the University of Crete offers to students of primary and secondary education STEM activities. One of these activities concerns the field of robotics. More specifically, the children try, taking into account the laws of physics, to build a robot - a car that will be able to overcome the obstacles that have been placed in front of it. They replace the wheels and see if the combinations they made helped the robot to be more efficient. http://h5p.edthe.edc.uoc.gr/ρομποτική/

6.7. Examples of educational provision about STEM education at the secondary education level, including higher educational programs

Higher educational institutions offer STEM-related workshops and exhibitions to lower and upper secondary students in several informal learning environments, such as science museums and science centers. In specific, academic departments that are related to research in education have developed and supported the development of school laboratory settings, such as the "Science in the City" and the "Natural History Museum", supported from the University of Crete. These centers promote the organisation of organised visits in which secondary students experience STEM exhibits, artefacts, laboratory settings and digital technology enhanced environments. In parallel, researchers working in informal learning domains promote research-based teaching and learning methodologies in order to facilitate increased students' learning in informal learning contexts. Moreover, innovative initiatives that include both researchers, teachers and experts in the organisation and implementation of the school visits are been applied in these contexts and informed guidelines and recommendations are been promoted to stakeholders in primary and secondary education.

Additionally, science centers supported by research institutes such as the "NSCR Demokritos" research center in Athens or the "FORTH" institute in Crete offer secondary schools the chance to visit the science centers and participate in guided tours and workshops for students. Also, non-academic partners in cooperation with academic personnel that specialize in science museums have developed museums such as the "NOESIS" museum in Thessaloniki that offers several STEM-related exhibitions (e.g. experimental Physics settings, ancient Greek Technology, planetarium) to students from all grades. The academic departments also allow selected students/classes from each school to visit the university campuses each year and to attend lectures related to cutting-edge STEM topics and get a guided tour in the STEM laboratories. The above practices contribute to the implementation of non-curricular STEM topics to school education as well as the dissemination of innovative STEM teaching practices through experimentation, engineering design and the meaningful use of contemporary digital technologies.

Students at the low and upper secondary level also experience several STEM festivals both on an occasional and on a regular basis. Concerning regular-based exhibitions, an educational STEM-related exhibition has been established, called "Researchers' night", in which secondary students are freely allowed to visit science centers and science museums in all big cities of the country every last Friday of September. In these exhibitions, researchers of the science centers introduce their research projects and outputs of the STEM research centers to the visiting students through several exhibition hubs. Students can optionally guide themselves to the hubs according to their personal interests, whilst they are also given the chance to interact with the researchers, pose them their questions and receive STEM career guidance. Furthermore, several students from some schools that implement STEM projects throughout the school year are given the chance to present their own work to peer students and visitors during the "Researchers' night" exhibition.

Another regular-based festival which is been organised every year is the "Computing at School" festival, in which students from several schools present their STEM projects that have developed throughout the year, with a specific focus on digital technologies and coding.

Students are also introduced to STEM projects developed from researchers and postgraduate students from the Technical universities. For example, the Technical University of Crete organizes every year an open event for secondary students called "Day of Science & Technology" During this event students come in contact with innovations and applications that are developed by TUC research groups (https://www.tuc.gr/index.php?id=13217&L=570).

Moreover, there are some master programs that refer to secondary science teachers' preparation for STEM education. Particularly, the National and Kapodistrian University of Athens offers a master program in STEM education and educational robotics (https://stemrobiticspostgrad.webnode.gr/) while the University of Patras in cooperation with the National and Kapodistrian University of Athens offers a master program on the Interdisciplinary STEM approach (http://stemeducation.upatras.gr/). Through these master programs teachers get familiar with the STEM approach, develop teaching materials following such an approach and implement them in real secondary classrooms.

Furthermore, the University of Thessalia offers one – year training programs in STEM education for primary and secondary science teachers (https://learning.uth.gr/tag/stem-training/).

Finally, the publication of the new international journal called "Hellenic Journal of STEM Education" aims to increase knowledge and enhance understanding of ways in which STEM epistemology can improve education, through the publication of high-quality peer-review empirical and theoretical research.

6.8. Best practice curricular/methodological models for the integration of STEM skills in general education subjects at the lower/upper-secondary level that exist in Greece, practical teaching/ learning arrangement in distance education

In our country, the gradual integration of STEM in the educational program is based mainly on skills workshops, experimental groups and after school programs. In STEM education, teaching takes place mainly through the implementation of student projects, which extend over a greater depth of time (more days or even weeks) and in which more teachers, from different disciplines, can be involved, so that students gain a complete understanding of the interdependencies that determine the function of the physical, but also of the digital, world. Physics, mathematics, chemistry, technology, computer science, engineering are connected as cognitive objects and interact integrated within projects. Participation in group projects is a key component of the educational process. In the project method, students work on a case-by-case basis in heterogeneous groups with roles defined by the instructor in the initial lessons, but as students get to know each other they become responsible for the way they choose to work, the performance of roles within the group and the harmonious and constructive cooperation. Through the implementation of STEM through projects, learners learn to reflect on the process of solving authentic problems and acquire skills such as critical thinking and collaboration.

Also, in STEM education it is common to use the teaching method based on problem solving. In a collaborative process of finding a solution to a specific problem, group collaboration, individual initiative and creative thinking develop .Students will have to identify the problem, divide it into sub-problems, formulate and test the hypotheses to solve the sub-problems in order to lead to the final presentation of the solution. Students themselves will have to come up with solution strategies, construct, test and then correct them to reach a final problem solving. Through Problem-Based Learning, students, in addition to acquiring knowledge, develop a range of critical skills, such as time management and work organization, creative and innovative thinking, observation, testing and communication etc. Students are asked to make the connection between the theoretical knowledge they acquire and their practical application and perceive a practice that has visible results determined by themselves.

In addition, the interdisciplinary approach is a fundamental component of STEM education. Contrary to the previous prevailing pedagogical conception of the delivery of an individual cognitive field to be memorized, the interdisciplinary approach places each cognitive object within a broader interdisciplinary context. For example, educational robotics is used as a tool for teaching several cognitive subjects in high school such as Physics (facilitating the learning of difficult concepts, such as linear smooth motion, measuring distance based on the perimeter of a circle, etc.), Mathematics and mainly Informatics. Specifically in Informatics, educational robotics is taught through Programming (Design and implementation of algorithms, Visual Programming Environments such as Scratch, BYOB, K-turtle, msw logo, Microworld pro, Starlogo TNG, Turtle Art). Educational robotics is not taught as a science in secondary education, but is a tool for learning and teaching other subjects. Students, through work plans, learn to design and distinguish the means and tools of the educational robotics environment. They also learn to take on roles, assemble the robot, become familiar with the robot's programming and guidance environment (movement commands, control commands, sensor control commands, etc.) as well as implement, control, and improve simple and complex robot guidance algorithms.

6.9. Possibilities and recommendations for the integration of STEM fields into the secondary school curriculum

The inclusion of STEM areas in the secondary education curriculum initially requires a substantial reformation of the curriculum so as to enhance Inquiry-based learning methodologies, as well as to focus on connecting school with real-world problems and everyday contexts. In specific, there should be provision for interdisciplinary projects based on project-based learning through the collaboration of teachers from all the related disciplines and expertise involved. Also, the school should promote children's interaction with state-of-the-art technologies by embedding core elements of such technologies in their curricula. Moreover, the school should be open to society and educate students to relevant societal problems and socioscientific issues that are related to the phenomena and topics that they are called upon to learn. Therefore, students should be trained to learn and practice informed views and argumentation methodologies by taking into consideration multiple dimensions of the related problems.

In terms of the above, it is highly recommended to support the creation of new interdisciplinary courses in the secondary school curricula. These courses should be autonomous regarding the discipline barriers and should engage all STEM discipline content knowledge and skills. Therefore, it is recommended that the course's syllabus includes indicative topics that are interdisciplinary in nature, e.g. contemporary cutting-edge science topics such as Climate Change, Nanotechnology, Artificial Intelligence etc or curriculum topics that are taught in a way that fosters their interdisciplinary nature e.g. by implementing historical-epistemological approaches in topics like Quantum mechanics. However, it is imperative that these courses should also provide the teachers with some degrees of freedom in order to choose their own topics and methodologies, according to their students' capabilities and interest, as well as the specific classroom contexts.

During these courses, students should be encouraged to make and reflect on interconnections between disciplines as well as to engage to experimental settings, to design and develop their own teaching material and to make use of contemporary digital tools. In addition, students should be engaged to out-of-school contexts and school visits to non-formal learning environments (e.g. science museums, science centers, workplaces etc. Finally, it is recommended that these interdisciplinary courses implement innovative assessment methods, that move away from traditional tests and exams. On the other side, the whole process of student's learning should be assessed, as well as the skills, epistemological consciousness and societal awareness developed.

Furthermore, regarding the existing courses in the curriculum that relate to STEM disciplines (e.g. Science, Mathematics etc), it is highly recommended that interdisciplinary connections with other disciplines should be explicitly emphasised during instruction. This could be done by: a) additional tasks or projects related to specific topics of the existing course's syllabus, b) by promoting the implementation of experimental sessions and engineering tasks that can promote the cultivation of interdisciplinary thinking and skills and c) by implementing interdisciplinary 'episodes', specific small parts of the lesson that integration of knowledge is aimed as well as epistemological reflection on STEM Integration.

However, prior to the implementation of such innovative actions, all teachers involved should have been trained on and become fully conversant with the fundamentals, methodology and implementation of STEM Education, along with core elements of related technologies such as e.g. open-source electronics platforms (eg arduino, rasberry pi). Therefore, informed professional development programmes are needed in order to prepare in-service and pre-service teachers for the implementation of STEM Education initiatives.

Moreover, schools with STEM-oriented curricula should be able to implement open learning classrooms and be properly equipped with relevant STEM laboratories, equipment and tools. Finally, it is imperative that these initiatives are designed and implemented by taking into consideration of equity and diversity principles, by promoting minority and underrepresented groups (e.g. due to race, gender, socioeconomical situation) in the STEM fields.

6.10. Needs of organisations/ entities in Greece in the field of STEM education with regard to the adequate competencies of teachers in distance teaching/ learning

Due to the existing conditions, distance education is applied more intensively. As a result, some organisations/entities have to offer distance STEM education. Thus, teachers should have developed competencies in how to be able to conduct STEM teaching in a distance context.

So they need to be able to plan, manage and coordinate teaching. In fact, they should monitor, adapt and evaluate the goals and processes of teaching / learning. Another skill required of teachers is to be able to use educational materials and new technologies in teaching. Using relevant technology effectively, teaching becomes even more effective. It is also important that they have to develop metacognitive and interpersonal skills for learning both individually and in professional communities. Negotiation skills are considered useful, mainly to be able to interact socially and politically with educational institutions and social actors.

Furthermore, teachers have to be able to design and use instructional scenarios for distance STEM learning. So they need to have additional skills related to distance education. As a result, other skills that teachers need to have in order to be able to apply distance STEM learning are to exhibit effective written, verbal, and visual communication skills. They should create a friendly and open environment, facilitate productive discussions and stimulate learners' critical thinking. In addition, they should employ appropriate types of interaction and to provide timely and informative feedback. Feedback is a very important element in distance education, because teachers are not in the same place with their students, thus the immediacy that would exist in face-to-face teaching is lost. Sometimes, teaching does not even happen at the same time, teacher and students interact in different time. For this reason, they have to ensure appropriate communication behavior within the given environment.

Generally, teachers should improve their professional knowledge, skills, and abilities, in order to be effective in what they do. Additionally, teacher education and professional development should focus on skills related to STEM and distance education. Teachers need to have competencies, in order to be ready to design and apply such a teaching. In Greece, there are not many programs that focus on developing these competencies in teachers. It is a new part that appears in the field of STEM education, because another factor, which is distance education, is added.

6.11. National strategies and current national curriculum in Greece with regard to STEM education concerning digital education readiness (using SWOT analysis)

The last decades, there have been recommendations for national educational policies that aim to the development of curricula that enforce students to elaborate 21st century skills, such as creativity and critical thinking, but also skills related to technology, engineering, and science. Already, since 2011, STEM education has to some extent been implemented in primary and secondary education through course called "project course" or alternatively "creative essay course". During this course, one teacher or a collaboration of two teachers work together with students (10th grade) on a project (e.g. developing a STEM artefact or engaging with an out of traditional curriculum topic) that they codesign and codevelop with their classroom students. Throughout the course, students work collaboratively and try to integrate knowledge in order to apply problem-solving and inquiry-based techniques. Students are also given the chance to participate to student exhibitions and festivals or competitions with their developed project and disseminate their work to peer students and the educational community. Hence, despite the fragmentary application of STEM education in Greece, some preliminary examples of this application could be regarded as successful to some extent.

Moreover, several curriculum courses aim specifically in developing digital competencies for STEM Education. Mainly they are implemented in the base of the Informatics courses, that are given to students from grade 1st – 6th for primary education and grade 7th – 11th for secondary education. During these courses students learn how to use digital software and hardware, how to code and develop digital projects, in which often they have to integrate knowledge and skills from other disciplines (e.g. mathematics, physics etc). Several STEM digital practices are also recommended to be implemented in traditional curriculum courses such as science, mathematics, albeit this approach has not been implemented to a great extent. Furthermore, students studying in technical and vocational high schools also attend several technology-related courses, in which several STEM disciplines are integrated through experimental practices and engagement or development of artefacts.

Concerning teacher education, since 2014, policymakers promoted teacher professional development programmes in training ICT, emphasizing the elaboration of technological literacy. In specific, organised extracurricular programmes, divided in two stages (A & B level) were established by IEP (Institute of Educational Policy). During the A level of the programme, in-service teachers were trained through small group workshops in using several educational software and digital material as well as the development of digital-related skills (e.g. design and development of online teaching material and school webpages). Subsequently, during level B, in-service teachers were trained in digital applications and skills that were specifically related to the discipline that they were teaching.

In addition, distance learning needs, occasioned by the Covid-19 pandemic, has led policymakers to develop necessary teacher professional development programmes in December 2020 targeting in the familiarisation and utilisation of distance learning tools, digitalised teaching materials, related techniques and digital informed methodologies. These initiatives aimed to enforce the development of in-service teachers' technological literacy, in order to enrich the implementation of digital technologies during in-person lessons but also in order to make teachers competent enough to implement educational methods such as blended learning and flipped classroom.

Finally, during the present school year 2021-22, national curriculum for primary education have also included workshops and courses that aim in development of 21st century skills, which include STEM education, while a pilot implementation of this project was carried out during the school year 2020-2021. Main targeting of the aforesaid workshops and courses is the development of self-regulated learning, cooperation, and self-improvement, through elaborating skills such as critical thinking, communication, creativity, problem solving, and students' digital and technological literacy. To assure the efficiency and success of this educational innovation, IEP (Institute of Educational Policy) provides in-service teachers related professional development programmes focused on 21st century skills including STEM education and Educational Robotics.

6.12. National strategies in the field of education, current national curriculum, and fields that (in)directly cover STEM education regarding teaching standards, innovative pedagogies and didactic materials used in cross-curricular investigation of digital education

Greece's Digital Teaching and Digital School's strategy generally, aims at integrating and incorporating Information and Communication Technologies (ICT) into the curriculum and everyday educational practice. The aim is to be:

1. for teachers, a means of supporting current pedagogical approaches for teaching, learning, exchanging good practices with colleagues in the "global village", and opportunities for continuing education.
2. for students a useful tool for learning, problem solving, developing critical thinking and their creative ability.
3. for the entire school community (students and teachers) a tool for collaboration among its members and communicating with the rest of the world through the creation of multiple "digital learning communities".

The current national curricula in Greece are centrally defined by the Ministry of Education and Religious Affairs and they target all students attending the same grade and education level. Until school year 2020-2021, there were no explicit fields that directly covered STEM education. On a voluntary base teachers could undertake actions on environmental education, health education or culture and arts oriented issues, using an STEM pedagogic approach.

From the school year 2021-2022, a significant change in Greek curricula is the skills workshops. Since September, skill workshops are part of the mandatory schedule of all Kindergartens, Primary and Lower Secondary Schools in the country, introducing to the school topics such as STEM, robotics, environment, entrepreneurship, etc. Taught time for skill workshops amounts to 2-3 hours per week for younger students and just one hour per week for Lower Secondary students.

Teachers had the opportunity to attend a 36-hour distance learning program organized by Educational Policy Institute (IEP), which is an institute that makes proposals on the school curricula, textbooks and other teaching materials. Complementary to the above there are also established some new structures for the scientific and pedagogical support and guidance of secondary education teachers, such as regional centres for educational planning (PEKES), Committees of Interdisciplinary Educational Evaluation and Support (EDEAY), Environmental Education Centres (KPE), etc..

In parallel, the user generated content Photodentro operates. Teachers and members of the wider educational community can either post their own digital content or search for digital content. The aim is to gather learning material, developed by members of the educational community who wish to share them, such as experiments, interactive simulations, investigations, images, educational games, 3D maps, exercises, educational scenarios and lesson plans.

At the same time another platform, called AESOP, offers digital didactic material, which can be used in cross-curricular STEM education. The Advanced Electronic Scenarios Operating Platform (AESOP) of the Institute of Educational Policy is a support website for the education community. Various scenarios for different subjects of primary and secondary education are available. All repositories are open to everybody, students, teachers, parents and anyone interested.

Finally, the national strategy referred to the Greek education digitalization strategy, aims at enhancing the technological infrastructure and the educational structures in order to create a high-performance digital ecosystem which will inspire its "inhabitants" to develop their digital skills. In addition, curricula are being reformed after almost 20 years, emphasizing the desired outcomes and digital skills, and horizontal training programs are underway for all our teachers, a key investment in the human capital of our education system.

6.13. Detailed needs of the organisations/ entities/institutions/schools in Greece in the field of STEM education with regard to the digital contents into the school curriculum in full compliance with the distance learning and teaching

Given the growing interest in, and relevance of, integrated approaches to STEM (science, technology, engineering, and mathematics) education, there is an urgent desire to understand the challenges and obstacles to developing and implementing integrated STEM curricula and instruction.

Undoubtedly , there are a lot of key issues emerged from the analysis of the state of affairs in Greece in terms of Science, Technology, Engineering and Mathematics (STEM) teachers' competence requirements and development.

Digital learning tools are invaluable when they're used by confident educators. In fact, when used appropriately, digital and mobile learning resources engage students–and they can even help boost achievement. Moreover, digital tools can help students learn maths and science, especially when used alongside a variety of teaching methods. But improvements in learning outcomes also depend on the type of learning environment.

However, most of Greek teachers are skeptical on the use of these tools that promote distance learning and teaching, describing them as a novelty in the Greek classroom reality as they are not familiarized with the methods. This is due to the effort required to implement a very different structure in an educational system that has a very established segregated STEM structure. Moreover, elementary teachers were more likely to believe that they were already integrating STEM subjects, seemingly because separate subject classes are not as commonplace, especially in the early grades.

To sum up the deficit in STEM skills is a matter of concern for national economies and a major focus for educational policy makers. Designed purposefully, digital badge learning trajectories and criteria can be flexible tools for scaffolding, measuring, and communicating the acquisition of knowledge, skills, or competencies.

The second major challenge that we recognize is teacher STEM knowledge and their professional mindset. Teaching integrated STEM requires some fundamental knowledge of how contexts provide opportunity to learn multiple STEM facets and concepts. Thus, teachers who do not feel that they have the knowledge or are not willing to learn the concepts or content rapidly are not likely to be willing or capable for supporting an integrated STEM approach to teaching and learning.

The following are some of the related barriers that have been identified to advancing STEM education regard to digital context. For this reason it is recommended: (a) preparation and shortage in supply of qualified teachers, (b) investment in teacher PD, (c) preparation and inspiration of students, (d) connection with individual learners, (e) support from the school system, (f) research collaboration across STEM fields, (g) content preparation, (h) facilities, and (j) lack of hands-on training for students.

It is important to give voice to the teachers and school administrators who actually have the needs and experience potential barriers in their ability to move towards integrated approaches in STEM.

7. Greece

7.1. 3rd Junior High School of Rethymno

Our school, 3rd junior High School of Rethymno,(Crete island) is located in the most central part of the city, opposite the municipal garden.

Three hundred and fifty (350) students study in it, divided into three (3) Grades, having five (5) classes each of them.

Therefore the total of the classes are (15) fifteen.

In the first Grade there are students aged (12) twelve years old.

In the second Grade there are students aged (13) thirteen years old. Finally, students (14) fourteen years old are in the third Grade.

25% of the students are immigrants or refugees (mainly from Albania, and few from Syria, Bulgaria, Romania, Moldova, etc.)

The total number of teachers working in our school is about (35) thirty five.

Each class wellcomes 20-25 students and is equipped with a laptop and a projector.

Classes start at 8.15 am and end at 14.00 pm where they leave the school.

There is a canteen at school, but students do not dine at school but at their homes.

The weekly schedule includes 4-5 hours of Mathematics, 2 hours of Physics, 1 hour of Chemistry, 1-2 hours of Biology, 1-2 hours of Geography, 1-2 hours of Technology and 1-2 hours of Informatics.

Our school participates in National programs related to Environmental education and Sustainable development.

For the last 4 years we have participated in four (4) E-Twinning European programs but is only the first Erasmus program that we participate (at the same time with another KA 229 on English language teaching).

We have also participated in European projects on alternative forms of energy production (hydrogen generator) and ESA's (European Space Agency) projects.

7.2. Previous experience with STEM education - projects, workshops

Our institution has valuable experience of participating in educational programs such as workshops and various projects as listed below:

European Program "Chain reaction 2013-2016" _«Chain Reaction: A Sustainable approach to Inquiry Based Science Education - Coordination and Support Actions (Supporting Actions)» (participation with the topics: Plants in Space and Alternative Sources of Energy)

e-TWINNING programs (participation with the topics: "Light me the way" 2021, ''Chemistry behind bread making'' 2020 , '' Traveling in different biomes'' 2019 Etna-Santorini:The rings of Fire 2018)

ESA PROGRAM (Food from Spirulina) 2016

Students aged 14-16 in all ESA Member States conducted experiments inspired by the alternative Micro-Ecological Life Support System (MELiSSA). "Food from Spirulina" is a biological experiment that proves to emerging scientists the important role of Spirulina, also known in the scientific community as Arthrospira platensis in the recycling of exhaled CO2 to O2

ESA WORKSHOP, IN SPACE ROBOTICS. Redu-Belgium 2017

ESA- ESEC, the European Center for Space Security and Training, in Redu, Belgium, is a center of excellence for cybersecurity services, housing the ESA Proba mission control centers, the Space Weather Data Center, the ESA Education Center (hosts permanent facilities dedicated to the training of training schools teachers and students under the ESA training program) as well as part of the ESA ground station network.This training offer is for an electronic robotics lab, which provides training to primary and secondary school teachers in the use of a space environment for teaching and learning technology and science. (Teaching Physics with Space) Redu-Belgium

DLR - SCHOOL LAB (German Center for Space) Berlin- Dresden 2018

Demonstration and participation in workshops in the fields: microgravity, robotics, virtual reality, organic photovoltaics, special materials and adhesives used in spacecraft, aircraft engines.

Rutherford Appleton Laboratory . Oxfordshire - London 2019

Demonstration and participation in workshops in the fields: Using Laser techniques in different types of scientific research, as Nuclear Physics, Astrophysics ,Health,Engineering, future materials.

CERN's International High-School Teacher Programme. Geneve 2019 This programme, which has taken place at CERN every since 1998, is designed for science teachers from all around the world to discover the fascinating world of particle physics. The programme includes lectures, on-site visits, hands-on workshops, discussions and Q&A sessions. Moreover, during the programme , all teachers collaborate in several working groups on various topics related to particle physics and its integration into the classroom. For example, teachers build particle traps in S'Cool LAB, develop and evaluate new tools for the CERN Open Data portal, run a medical applications hackathon at IdeaSquare, or update educational resources for the IPPOG database.

7.3. Previous experience with STEM education - in everyday education

In Greece, STEM education has not so far been integrated into the daily educational reality as it is not provided by the official Curriculum.

Nevertheless, in the context of the distinct subjects of the Natural Sciences (Biology, Geography, Physics, Chemistry) in collaboration with teachers of Informatics and Mathematics, we are using the possibilities provided by STEM education.

Utilizing the laboratory of Natural Sciences, Informatics and Technology and planning appropriate activities we activated our students through properly designed STEM activities

Moreover, during the period of remote learning during the COVID-19 pandemic, we combined the STEM education with digital environments and digital learning platforms such as E-class, Edmondo, Google classroom, Teams, as well as virtual simulation environments such as Phet Colorado. This combination of STEM education with the help of digital environment has enabled our students to cultivate to the maximum some desirable skills of the 21st century (4Cs), such as effective communication and collaboration (group collaboration), the development of critical thinking for STEM problem solving and creativity.

These skills proved to be valuable, as they strengthened our students on the one hand cognitively and on the other hand prepared them sufficiently and strengthened them so that through STEM intervention they acquired skills that will enable them to innovate and produce new knowledge.

7.4. Participation in project Innovative Schools Teaching&Learning in DIGITAL STEM LABS

In Greece the emphasis in the curriculum for general education, until last year, focused on the so-called "hard" skills: reading, writing, numbering and knowledge-based approach.

Moreover, the volume of teaching material creates stress in terms of its management and very often led to deterrent conditions for further elaboration of even everyday school skills. It also led to sterile memorization and incomplete integration (indications from PISA).

However, from this year, for the first time, the course of the skills laboratory is introduced in the curriculum-in primary and lower general education- in which the STEM approach appears in the thematic unit of creation-innovation.

The STEM method seeks to transform from the level of traditional teacher-centered teaching to teaching where problem solving and exploratory learning will play a dominant role in the curriculum, while students' creative involvement in solution discovery will be required.

STEM provides opportunities for skill development by encouraging children to answer questions and engage in playful science, math, engineering and technology activities. It is really impressive the change of participation and interest shown by the children with the scientific fields of STEM.

Through the implementation of STEM through projects, students are given the opportunity to explore their imagination to find imaginative solutions. Curious students invest in their education and are the driving force of innovation and discovery. Students learn to think about the process of solving authentic problems and acquire skills related to globalization in education, as it focuses on critical thinking, teamwork (collaboration), literacy in the media while it has been reported to reduce the knowledge gap between students from different countries.

Since Education globally is changing rapidly, our participation in the project INNOVATIVE SCHOOLS: TEACHING & LEARNING IN DIGITAL STEM LABS is very important because STEM practices will help us to transform the traditional teacher-centered courses into ones where problem solving and discovering-exploratory learning plays a predominant role in the curriculum.

We believe that our students will develop skills that will encourage them to engage in activities in science, mathematics, engineering and technology.

Participating in the project INNOVATIVE SCHOOLS: TEACHING & LEARNING IN DIGITAL STEM LABS will help us provide a stimulating way of learning that will engage our students in numerous ways such as learning to communicate, argue, disagree and cooperate.

Since STEM's activities focus on real-world problem-solving, our students will learn by finding solutions to everyday problems and will also learn while teaching them that a problem can be solved in various ways.

For all the above advantages, the participation of our school in this program is very important.

7.5. Relevant policy frameworks in the field of valorisation and interpretation and appropriate presentation of STEM education in Greece

In Greece STEM education is not included in the official Curriculum of General Education in Secondary Education and for this reason there are no provided structures or suitable laboratory spaces. The logic of STEM education prevails in the private sector of education and many STEM training programs are implemented by organizations and individuals.

The interdisciplinary methodological approach proposed by STEM education has been adopted by the teachers of Secondary Education, mainly in the field of Natural Sciences and Informatics. In Greece, STEM education takes place to a small extent. It is essentially at an initial pilot level, mainly in primary and early secondary education.

Nowadays, society and economy are changing rapidly and in order to sustain the future growth, more well-educated people in STEM education are needed. Both educators and official institutional actors understand the need for Greeks, as European citizens, to further invest in the modernization of general education through STEM education. Secondary education's Curricula are currently under review and new proposals may be able to incorporate the logic of STEM education. The Greek government, following the European standards for training, has enacted a two-hour STEM course for the first class of the technical high schools.

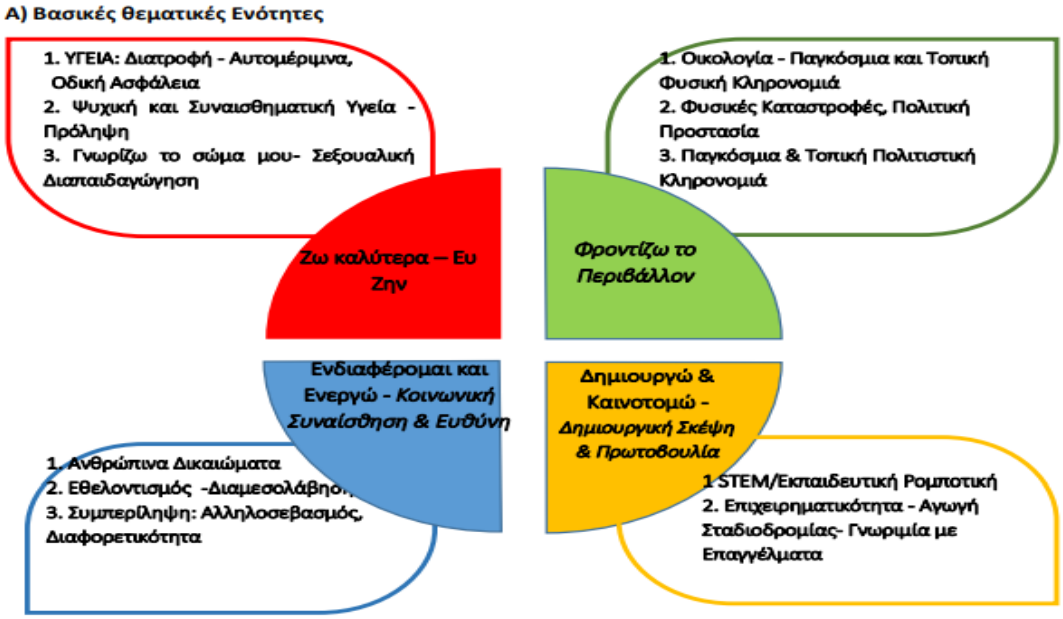
Just in the current educational period 2021-2022 the course "skills workshops" is introduced, the **STEM methodology appears in the section "act - innovation" (yellow field) with application in educational robotics.**

The other three sections are:

'Environment' (green area) with subsections, ecology, natural disasters, cultural heritage)

'Living better', (red area) with subsections, healthy eating, mental and emotional health, sexual education.

'Social responsibility', (blue area) with subsections, human rights, volunteering, mutual respect, diversity



The introduction of a new course creates demands for appropriate support and use of the available educational technology. It has been well documented that enriched learning environments present a solution to the performance gaps that may exist in a classroom. The organization of a teaching methodology and the creation of suitable web technologies and online labs will help to embed the STEM courses in the educational reality in Greece.

Summing up, the need to provide STEM education to the youth of our country is more urgent than ever, as any efforts recorded so far are limited in the sense that they are not used horizontally at every level of general education. What is more, they have a small scope of application (only in A EPAL class) and the utilization of STEM education lags behind due to the lack of possibilities for relevant training and its poor application in the daily school reality.

7.6. Relevant good practices and case studies in the field of valorisation and interpretation of STEM education in Greece in formal and informal education

First good practice

STEM Lesson: Homemade or commercial toothpastes ?

Overview & Purpose

During recent years there is a tendency of the people to conduct their lives in ways consistent with sustainability, which means respect to the environment resources. These thoughts urged us to make homemade toothpastes with simple pure materials.

This lesson will be taught in the lab, as a lab lesson, where all students will participate preparing homemade toothpaste by scratch.

A predominant idea is to develop an alternative way of learning, which will motivate all students independently of their knowledge targeting in exploiting their individual skills.

Teaching Method

The new tendency in education is to find alternative methods to motivate all students to participate. In addition students must learn to communicate and collaborate, research, collect and synthesize information.

The method which will be followed is based in cooperative and inquiry based learning with the help of ICT.

Students are going to develop hands-on activities in a chemistry lab, unfolding their skills beyond a concrete cognitive type lesson

Objectives

The inspiration to prepare homemade toothpaste came from the chapter of mixtures in the chemistry course. To understand better the properties of a mixture, the students prepare their own mixture (a toothpaste) by scratch, so they easily realize how in a mixture the properties of its ingredients are preserved.

Most of the materials used were driven from everyday life (as baking soda, salt, etc).

Extended research on the internet was carried out in order to find out the proper references.

In addition, our work was based on a previous project, where our school participated, about science in everyday life.

Activity and Method Description

The students are searching the internet to find information about homemade toothpastes. Then they are divided into groups and assess the data they have collected. After many tries and experiments we found the most suitable method for us.

Baking soda and salt are thoroughly blended with glycerin till a creamy mixture is produced. Other ingredients are added at the end of the procedure.

The most successful recipe for our toothpaste consisted of: 45% baking soda, 16% salt (table salt), 29% vegetable glycerin, 8% water, about 2% citric acid, and essence oils. All percentages are w/w.

The abrasive and whitening properties were tested by cleaning the shell of eggs, which were previously dyed with natural pigments extracted from black tea, onion, and red cabbage.

A more detailed description will be given in a powerpoint presentation

Assessment

The assessment of the project was made with an evaluation sheet

Teacher : Georgolios Nikos

School : Experimental high school of Thessaloniki University

https://www.youtube.com/watch?v=Jq6DFBz0KMA

Literature

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Second good practice

Type of information	Contents
Title	**"In the traces of Pythagoras" (a programming robots approach of Pythagoras theorem)**
Link	**https://steamonedu.eu/platform/node/node/74**
Abstract	Brief teaching of the Pythagorean theorem to 20 students coming from seven European countries, i.e., Poland, Portugal, Spain, Finland, Romania, Italy, and Germany, in the frame of the Erasmus project ran by our school, entitled "Learning with Arts". The teaching combined the theoretical presentation of the Pythagorean Theorem with its practical application, using two specially made LEGO EV3 robots. The purpose of the course was to help students get to know and 'experience' the Pythagorean theorem.
Language	**English**
Duration	**3 hours**
KeyTerms	**Geometry, Robotics, Mathematics, Pythagorean Theorem, History**
STE(A)M discipline	**Technology, Engineering, Arts, Mathematics**

Country	**Greece**
Author	**Petros Stavroupolos**
Educational framework	· **Audience competence: Beginner** · **Educational/EQF level: 1** · **Age Range: 10-13**
Educational details	
Description of the practice	Initially, Pythagoras and the Pythagorean Theorem were presented in combination with examples of calculating the length of the hypotenuse of a right triangle. Then a worksheet was handed out and the students, divided into groups, were invited to calculate the length of the hypotenuse of a right triangle according to the examples they had been earlier exposed to. During the next step, the students learned about the LEGO EV3 robotics kit and its programming environment. Also, an interactive whiteboard featured an exercise in Geogebra that showed the relationship between the perimeter of a circle and its calculation of the distance a robot covers when its wheel makes a complete rotation. There was also a presentation on π = 3.14 and on the way of calculating the perimeter of a circle, which was necessary for the experiential exercise that would follow.

	Finally, the guest students were given an EV3 robot, made by the pupils of the robotics group (E-F class), with a marker adapted on it, so that it could write on paper. Also, each group was given a sheet of paper designed with two vertical lines (vertical triangle lines), as well as rulers on how to measure their length. The students of the robotics group (E-F class) had created a program in the programming environment of LEGO EV3, which took as inputs the values of the perpendiculars of a triangle and calculated the hypotenuse of the triangle, and moved the robot for the corresponding period.

	In this phase of the task, the guest students were asked to count the two vertical lines and then enter them into the program, download them to the robot and draw the underlying sheet on the sheet they were earlier given, confirming the correct calculations made following the rules of the Pythagorean Theorem.

List of resources	· https://steamonedu.eu/platform/sites/default/files/2020-06/Pythagoras-2.pdf · https://steamonedu.eu/platform/sites/default/files/2020-06/Pythagoras-Worksheet.pdf
Assessment	The STE(A)M practice is complicated: 12/12 The STE(A)M practice is holistic: 9/9 The STE(A)M practice is problem oriented: 8/9 The STE(A)M practice is practical: 12/12 The STE(A)M practice is social: 11/12 The STE(A)M practice is transferable: 6/6 The STE(A)M practice is based on collaboration: 7.5/9 The STE(A)M practice addresses professional development: 5.5/6

7.7. Examples of educational provision about STEM education at the secondary education level, including higher educational programs

First application

"Robotics with recyclable materials"

The proposed training material aims to suggest teaching methods and skills assessment for the topic "Create and Innovate - Creative Thinking and Initiative", enhancing the learning skills of the 21st century. (current curriculum 2021)

• Critical thinking problem solving through computational thinking.

• Communication transfer of ideas.

• Collaboration Working with others.

• Creativity artifacts.

Students will be involved and activated by presenting a ready-made robotic construction from recyclable materials. They will explore this construction, that is, what materials it is made of, how it was assembled, how you move it, thus demystifying the robotic structures and they will realize that it is nothing more than programmable machines. They will be encouraged to build the "body" of such a robotic construction with simple recyclable materials. In addition, they may be encouraged to look for creative, new recyclable materials where possible, to replace the proposed construction materials. Then explore the basic concepts and structures of programming, through the friendly programming environment Ardublock and the Arduino platform, required to give "life" to robotic construction overcoming learning difficulties, thus increasing the feeling of confidence and satisfaction. Motivated by the activation of the construction, they will create pieces of code required for the individual functions of the robotic construction, will experiment and will interact with it. By reflecting the new knowledge through the

process of acquiring it, they will finally compose the required parts, in order to make the robotic construction functional.

Suggested activities

1.1 Educational visit to a material recycling area.

1.2 Activity of registration of recycling bins in the local community.

1.3 Create a poll for recycling.

2.1 Creating digital

list of materials that can be used in the development of a robotic mechanism.

2.1 Creation of videos of the reuse of recyclable materials (methods and ways of their utilization).

3.1 Articles in a local newspaper about the importance of recycling.

3.2 Creating videos - spots of the importance of recycling for modern technology.

4.1. Comprehension activities of materials in terms of density, volume and size.

5.1 Creating a copy of a robotic mechanism in 3D (TINKERCAD).

5.2 Creation of UNPLUGGED ROBOT (Application of Engineering design according to the Massachusetts Department of Education. (2006).

5.3 Creating a PLUGGED ROBOT with MICROBIT

engineering design according to the Massachusetts Department of Education. (2006).

6.1 Creation of a different model of the robotic mechanism

6.2 Verification activities

7.1 Writing activity in the local press.

7.2 Online writing activity.

7.2 Creating a robotics team.

Dr. Apostolos Xenakis, P.D. 407/80 University of Thessaly, (seri.cs.uth.gr)

Dr. Konstantinos Kalovrektis, Spyros Brentas - Informatics, graduate of EPPAIK ASPAITE Volos

Example of application of the implementation methodology in collaboration with institutions

a) Hellenic Educational Association STEM. (E3STEM, www.e3stem.edu.gr)

b)SERI Scientific Team http://seri.cs.uth.gr/

c) "Laboratory of Educational Applications of Computer Science and Educational Technology" of Higher School of Pedagogical and Technological Education (ASPAITE) https://www.aspete.gr/index.php/en/

https://scientix.ellak.gr/timetable/event/ekpedeftiki-rompotiki-kataskevi-me-anakiklosima-ilika-vasismeni-se-anichto-iliko-ke-logismiko-gia-steam-drastiriotites/

The Organization of Open Technologies (EELLAK), with the aim of promoting STEAM and Educational Robotics through Open Technologies and Open Source Software in Primary and Secondary education, formed a scientific committee of members of the academic-research community. (https://eellak.ellak.gr)

The task of the scientific committee is to contribute to the demarcation of STEAM epistemology in the educational community through actions and publications, the coordination as well as the configuration of STEAM teaching seminar material for teachers participating in https://scientix.ellak.gr/, at https : //robotics.ellak.gr/, at https://edu.ellak.gr/mitroo_ekpedeftikon/ as well as in other corresponding actions.

The aim of the scientific committee is to act as a bridge of knowledge to bridge the gap between the digital applications / tools that have been developed and used in higher education (Universities) in relation to secondary education to enhance STEAM through teaching scenarios.

Second application

"Mission to Mars". A distance learning program during the pandemic covid-19

Summary

A space scenario of a mission to Mars in 2065 formed the basis of an educational program of the Rethymnon Laboratory Science Center and NASA training programs, https://www.nasa.gov/stem-at-home-for-students-9- 12.html structured in a playful way in which groups of students of A 'Lyceum and C' Gymnasium participated, from schools of the prefecture of Rethymno. In this context, the students worked in groups as members of a scientific team that was called to face the challenges of the project. The purpose was to explore the possibilities but also the difficulties created in an asynchronous digital environment. Questionnaires were given to the students for the data collection. The results reflect the positive evaluation of the students for the interdisciplinary approach proposed by the program as well as concerns related to distance learning.

Space seems to be a privileged field for the Natural Sciences, as a special space, which with proper planning it can provide incentives for students to learn, collaborate and develop skills. In particular, the issues of colonization of other planets are of interest both in terms of their technological dimension and in terms of other aspects of economic and social life, thus making a digital activity like this suitable for application in both formal and informal learning environments (Salmi et al. , 2020).

Research data show that similar "space scenarios" have been used as didactic interventions, as the existence of a "story-scenario" combined with real data and problems of a space mission to Mars, results in the mental engagement of students with parallel STEM development. (Mathers et al., 2012. The active participation of students in space mission simulations and at older ages, has been studied and has shown that their participation has positive and lasting results both in terms of their attitude towards science and their subsequent professional involvement with space science related space (Afful et al., 2020).

Description

The invitation to the students to participate in the program stated that we are in the year 2061 where a mission is going to be organized in order to create a permanent colony of people on the planet Mars. Student groups would be the scientists who have an advisory role in the mission. 12 groups of students from 8 different schools, 28 boys and 26 girls responded to the invitation.

A program that is organized asynchronously needs the existence of an environment that will allow the organization of activities and cooperation between participants. The e-class platform was selected (https://eclass.sch.gr).

It should be noted that due to health conditions it was known in advance that (at least initially) a live meeting would not be possible. This posed a serious obstacle as there was no acquaintance with the students. It was therefore decided the participation of a teacher from each school who would have the role of mediator.

The presentation software genially (www.genial.ly) was used for the organization of the material in its free version. The platform genially enables the creation of attractive interactive content that can be incorporated with content from other sources such as audiovisual material from youtube (www.youtube.com), interactive images from thinglink (www.thinglink.com), content from e-me platform etc. This software was the main body on which the content and links of the activities were integrated. The modules of the e-class were used for the submission of the activities and the module of the assignments was preferred over the exercises, as in the former there is the possibility of feedback from the teachers, while in the exercises such a possibility is not included.

The second section aimed to motivate students' cooperation and to highlight their perception of scientists and scientific teams. The third section presented basic knowledge about the solar system and the planet Mars and then the next three sections deal with the journey itself.

The activities were related to three topics from the preparation for the trip. The first concerns the design and testing of a paper rocket (Figure 1). The second deals with the supplies of food required for the survival of the crew and asks the students a) to suggest some food from the Cretan diet that could be suitable for consumption on the spaceship, b) to participate in the creation of an article in wikipedia related to space meals and c) create a daily menu and calculate the total mass of food required for the trip. The third activity of the section concerns the calculation of the time that is suitable for the planning of the launch based on the positions of Earth and Mars and the use of geometric methods. It is clear from the above that this module requires a combination of engineering (in the design and flight tests of the rocket), chemistry and biology (in food) and finally physics and mathematics (for the calculation of the launch window).

In order to evaluate the program, an attempt was made to investigate the views of the students by using a questionnaire and during the meetings, on modern sessions, of the opinion poll tool (www.mentimeter.com). The questionnaire was anonymous and included questions to assess: (a) the students 'cooperation in groups, (b) the communication of the members involved in the action (c) the students' interaction with the material.

All the content developed is freely accessible in the e-class at the link: https://eclass03.sch.gr/courses/4100115116/

Conclusions

The results of the research showed that the combined use of the field of distance education with activities that enhance the skills of the 21st century was positively accepted by students. As already noted in the literature, the combination of asynchronous and modern teaching approaches, marks a significant change as it requires a transition from collaborative processes in the laboratory environment to self-regulated learning using e-learning environments (Eljack, 2020, Evans et al. , 2020). This combined utilization mobilized the learning interest of the students and created a positive predisposition for the proposed activities, giving us the opportunity to think about the implementation of such programs even in the period of open schools in the future.

Kostas Chalkiadakis – Alexandra Droubogianni – Giannis Sgouros 2021

Literature

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7.8. Best practice curricular/methodological models for the integration of STEM skills in general education subjects at the lower/upper-secondary level that exist in Greece, practical teaching/ learning arrangement in distance education

Understanding brain function requires the use of new learning methods to maximize each type of intelligence. We understand that the use of many didactic methods, methodically by the teacher will result in student efficiency. Constructive learning makes the teaching process particularly enjoyable not at all compulsory. Our purpose must be the "launching" of learning and the birth of the situation in which the student will seek to learn voluntarily, not to get a good grade, without being distracted by anything external, in his need for learning.

The technology in turn supports the theory of multiple intelligences with the so-called "triple coding".

The developers of the programs use three types of intelligence to transmit information, as it has been proven that this way students learn more easily. So they sharpen logical intelligence with the transmission of information, spatial vision with the colors and images they use and verbal, with the terms they employ.

Learning through digital tools achieves what is the purpose of a proper educational process: the personalized approach to knowledge without in any way ignoring the direct didactic feedback to students that pushes them to love and constantly seek knowledge (Unesco,bureau of education)

Inquiry-based learning is one such approach, whose effectiveness is higher in science-based teaching and is recommended as a critical element in science pedagogy. Cairns, D.; Areepattamannil, S. Exploring the Relations of Inquiry-Based Teaching to Science Achievement and Dispositions in 54 Countries. Res. Sci. Educ. 2019, 49.

Innovation in STEM integration is a mechanical gear-like system in which one part is interdependent to run the cycle smoothly. Knowledge of pedagogy and technical content, when combined with digitalization, creates a platform or space for innovation.

It is recommended to combine the traditional content knowledge and pedagogical knowledge with upgraded e-learning knowledge.

The future study perspectives for the K12 pedagogy demand the incorporation of online and e-learning platforms in the curriculum. These changes could bring about fruitful results for STEM students and will make K12 students better prepared to grasp the technical parts of courses faster.

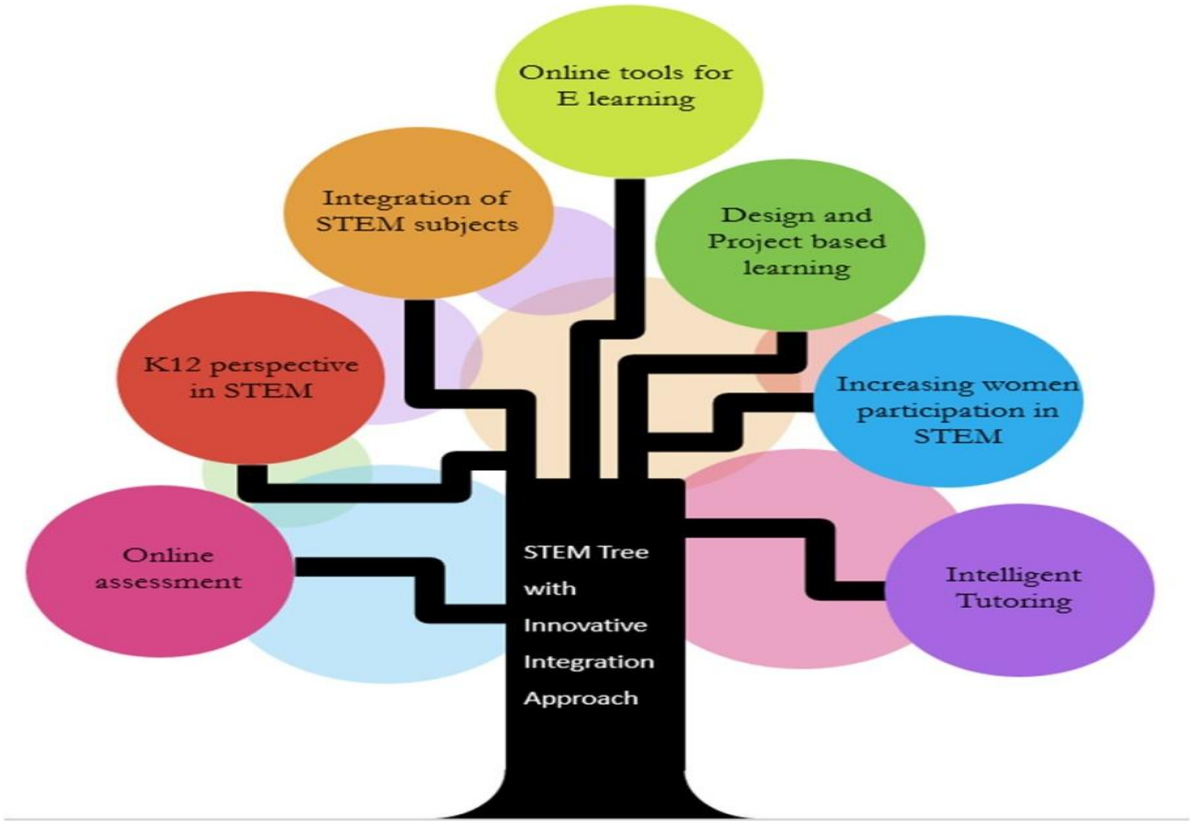
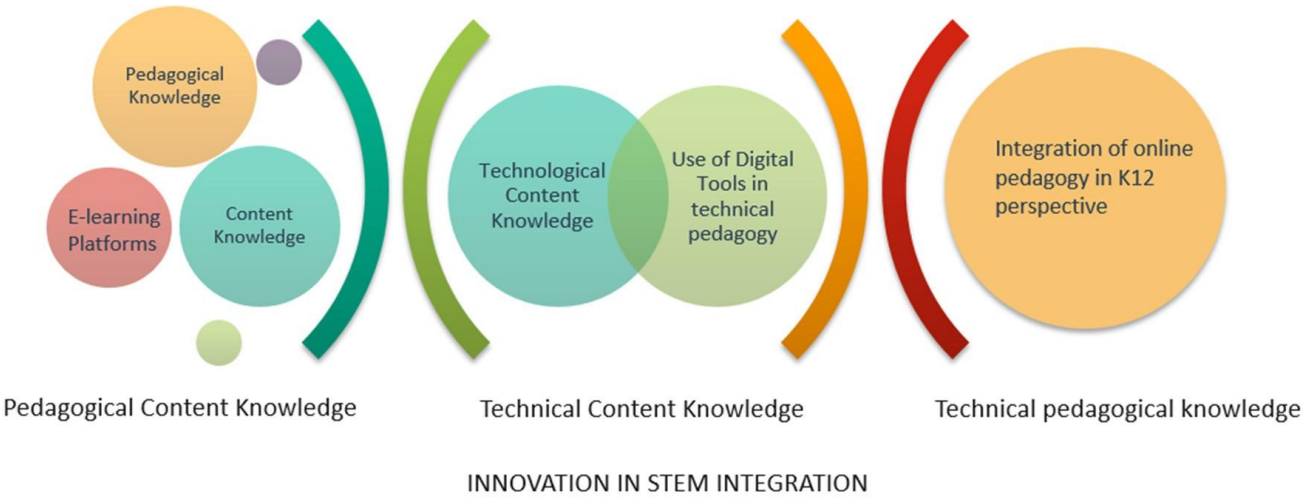


Figure 1. STEM tree with an innovative integration approach.

The STEM tree can flourish better with a nexus of amalgamated knowledge fields under one roof housing knowledge.

Figure 2. Integration flow in pedagogy.



Educ. Sci. **2021**, *11*, 319.https://doi.org/10.3390/educsci11070319https://www.mdpi.com/journal/education

7.9. Possibilities and recommendations for the integration of STEM fields into the secondary school curriculum

The modernization of STEM education cannot be differentiated using a black or white perspective. STEM consists of various shades of grey. Optimization of skill-sets and related tools can only serve as a solution when merged with innovation.

There cannot be any single concrete solution to STEM pedagogy modification, as the world is ever-changing, and so are teaching methodologies. Tailor-made innovations as per the requirement of educators with proper training can go hand in hand in the long run.

Skill development of educators in pedagogy is as important as technological advance- ments. The new educator generation will have to be familiar with the technology in order to lead to academic success.

STEM pedagogy will see transformation only if the old, well-defined concepts of content knowledge shake hands with the novel modules. This gap needs STEM researchers' deliberate attention, as the more this gap widens, the more challenging the task will become for educators.

Some of possibilities / recommendations for the wider the integration of the STEM fields into the secondary school curriculum will be :

1. Requirement of good and enhanced digital competency of teachers in online availability of tools to be incorporated in online pedagogy
2. Educators with online lab skills , development through platforms such as GoLabs to enhance inquiry learning
3. Incorporation of cloud modeling and simulation skills for project learn in pedagogy activities.

4. Skills-based on visualization tools such as ChemSketch, ParaView, and computational visualization

5. Broadening STEM areas in social psychological skills to build girls' confidence in STEM and uncapping their potential as resources.

6. Implementation of computer-aided design tools in pedagogy such as 3D in the early stages of STEM integration.

7. Enhance the digital classroom learning among school students with online social learning platforms.

8. Promotion of young pedagogy mindful.

9. Research temperament development among teachers with field experience of laboratories

7.10. Needs of organisations/ entities in Greece in the field of STEM education with regard to the adequate competencies of teachers in distance teaching/ learning

The primary concern in schools, colleges, and research institutes emerged with government authorities' lockdown situations. Classes suddenly had to make a transition to online instruction. The readiness of pedagogy educators and management is still an issue. Such a situation has not been observed on such a massive global scale in recent times. The educators trained for face-to-face pedagogy were forced to look for online solutions in pedagogy.

What are essential skills of a successful online distance educator in higher education?

Based on the synthesized results, there are six essential skills and sixteen outputs for performing those skills:

1. Interaction

- Guide and maintain interactive discussion
- Provide timely feedback
- Encourage peer learning
- Advise and counsel students

2. Management

- Monitor and evaluate student performance
- Facilitate presentation
- Introduce support services to students

3. Organization/ instructional design

- Provide clear learning outcomes, objectives, and expectation
- Organize materials and activities clearly and well
- Identify students' learning styles/needs
- Conduct instructional design effort
- Present materials and activities
- Provide a variety of learning activities

4. Technology

- Utilize technology in a competent manner

5. Content knowledge

- Deep knowledge in content area

6. Teamwork skills

- Collaborate with technical/support skills

The skill areas are ranked from 1-6 in order of importance. The outputs are grouped by area first, and then by importance. Not surprisingly, the ability to stimulate and facilitate interactions is the most important skill that online distance educators should possess. Even though many educators urged the competency of technology in online teaching, this ranking also presents a trend that online education is driven by pedagogical concerns instead of technological concerns. Another interesting finding is the relative importance of content knowledge. It seems that in an online environment, educators' mastery in the content area is important, but their ability organize and present content information to students is more important.

References

Analysis of essential skills and knowledge for teaching online Jia-Ling Lee Atsusi Hirumi University of Central Florida (2004)

In-service educators currently implementing STEAM training in their classrooms realized the following challenges in implementing integrated STEAM approaches (Shernoff et al. 2017):

1) lack of time for collaborative planning,

2) lack of time for teaching,

3) insufficient school and organizational structure (eg planning),

4) difficulty in evaluating STEAM achievements,

5) lack of resources

6) insufficient teacher training

In Greece, from the end of 2020, a training lasting two months (20 hours) began, for each specialty of teachers related to distance education. This training took place under the umbrella of the Greek Ministry of Education and was carried out by counselors and education staff as well as experienced educators.

The training of the educators lasted 6 months (380 hours) in designated training centers throughout the territory.

However, this training focused mainly on technical skills such as the use of the webex platform as well as the digital teaching tools e-class and e-me and not at all on pedagogical teaching methods. As a final product, the trained teachers had to present a didactic scenario of their interest using the above digital tools.

In the past, the process of enriching the knowledge and training of teachers was constantly alive through initiatives undertaken and implemented by members of the educational community (teachers, training coordinators, structures such as the Laboratory Center of Natural Sciences, Directorates of Education, etc.) . A significant percentage of these actions took place voluntarily, with a sense of individual and collective responsibility and a lack of central organization.

7.11. National strategies and current national curriculum in Greece with regard to STEM education concerning digital education readiness (using SWOT analysis)

SWOT Analysis towards Didital Education:

S	**STRENGTHS**	**Students:** • Excitement about the technology based online learning environment • Online flexibility learning and technology navigational independence **Lecturers:** • Customized and structural e-learning teaching sessions • May experience better and faster communication towards Students
W	**WEAKNESSES**	**Students:** • Insufficient capability to link technological design • Unstable Internet connectivity • Interaction of students during Online Classes • Lack of Online Equipments (laptops, pc's, android mobile phones) **Lecturers:**

		• May receive better classroom evaluations in the face-to-face classroom than online teaching • May encounter difficulty in mastering online teaching because of several technology based advancement.
O	**OPPORTUNITIES**	**Students:** • Increase of available digital knowledge share expansion • Lower costs and reuse content for any E-Learning online courses **Lecturers:** • May gain competitive edge over traditional face-to-face colleagues • May offer departments scheduling flexibility when trained

T	**THREATS**	**Students:** • Repercussions of mental health of students • High drop-outs of students • Lack of E-Content Policies in different institutions referring its' online e-Contexts **Lecturers:** • Have doubt about the integrity and effectiveness of online teaching and e-learning towards learners or students • Reduced teacher and students' physical engagement • Lack of motivation by teachers

STRENGTHS:

STUDENTS:

Excitement about the technology based online learning environment: Students' enjoyment and not boring online classes can truly be appreciated by students towards the benefits of a technology- based tools and equipments during home quarantine experiences.

Online flexibility learning and technology navigational independence: It allows a lot of flexibility (Dobre, 2010; Hsieh & Cho, 2011), accessibility in terms of geographical independence and thus a lot of coverage without substantial cost for traditional classroom training.

LECTURERS:

Customized and structural e-learning teaching sessions: The e-learning approach made by lecturers or teachers using online platforms towards their students are now customized and structured, because it opens expanded learning time to attain academic pursuits.

May experience better and faster communication towards Students: (Taylor, 2002) found that faculty experience better and faster communication with students; the online environment helps faculty blend their unique teaching styles and abilities into their sites.

WEAKNESSES:

STUDENTS:

Insufficient capability to link technological design: E-Learning management has an insufficient capability to network technology based framework of training services with the basis of a psychological mechanism by its e-learning processes that are being opposed by any traditional classroom environment.

Unstable Internet connectivity: Slow internet network connectivity during the E-Learning sessions and other lectural activities online. This may affect the E-Learning progress of the mentees towards their learning development.

Interaction of Students during online classes: The interaction between the trainer and the trainee is very limited and thus poses chances of lack of collaboration, communication and mutual knowledge sharing (CCL, 2009).

Lack of Online Equipments (laptops, pc's, android mobile phones): Student might be having problems on the use of online devices or equipments, such as laptop computers, android mobile phones, because of unlimited financial resources entirely.

LECTURERS:

May receive better classroom evaluations in the face-to-face classroom than online teaching: Aligning course goals with activities and measurements, and providing clear assignment instructions. Despite of all the preparatory online work, faculty who teach F2F sections receive better student evaluations than online faculty (Mintu-Wimsatt et al., 2006).

May encounter difficulty in mastering online teaching because of several technology based advancement: Faculty new to online teaching find that time efficiency occurs after mastering multiple technologies, continuously upgrading technology skills, understanding and applying Quality Matters (QM) standards, and refining course sites (Mintu-Wimsatt et al., 2006). Likewise, teachers who are not into technology base online teaching platforms before, can make their online teaching even worse, because of lack of technical knowledge and poor online systems familiarization.

OPPORTUNITIES:

STUDENTS:

Increase of digital knowledge share expansion available: Several teaching experts said that there are numerous and a positive increase of knowledge , both quantitatively and qualitatively, share for digital learning and virtual learning against classroom learning.

Lower costs and reuse content for any E-Learning online courses: Relatively decrease in cost, expenses, and the reuse of content for e-learning project courses.

LECTURERS:

May gain competitive edge over traditional face-to-face colleagues: For faculty, those who are trained in online teaching gain a competitive edge over those who do not. Technology-trained faculty business schools scheduling flexibility (De los Santos, E., Zanca, N. A. 2018).

May offer departments scheduling flexibility when trained (De los Santos, E., Zanca, N. A. 2018)***:*** Well-trained faculty who can use online platforms while teaching and continuously practice e-learning can possibly get working flexible schedules for some departments.

THREATS:

STUDENTS:

Repercussions of mental health: The pandemic has had repercussions not only on the educators, but on students as well. Students and educators around the world have suffered depression, anxiety, and mood swings.

High drop-outs of students: The flexibility and autonomy of the learner often does not guarantee their performance in learning and the results in higher drop-outs (Dobre, 2010).

Lack of E-Content Policies in different institutions referring to its' online E-Contexts: Lack of government policies and legislation regarding courses and e-learning contents adds to lack of quality standards and quality controls and standardization of e-content production and delivery mechanisms resulting in varying impacts of e-learning in different organizations in differing contexts (Demiray, 2010).

LECTURERS:

Have doubt about the integrity and effectiveness of online teaching and e-learning towards learners or students: Nationally, faculty continue to doubt the integrity of online programs (Lederman & McKenzie, 2017), and its effectiveness to deliver e-learning development towards students.

Reduced teacher and students' physical engagement: The implementation of online teaching and online learning diminished physical engagements between teachers and students. Just like a typical mandatory regular classes wherein students or learners can go to their respective classroom to attend a normal way of classes. By means of online teaching and online classes, it limits personal engagements, and physical contact within.

Lack of motivation by teachers : Multiple studies also point out the lack of motivation by teachers in engaging in e-learning and its support by creating e-learning materials and implementing them (Demiray, 2010).

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7.12. National strategies in the field of education, current national curriculum, and fields that (in)directly cover STEM education regarding teaching standards, innovative pedagogies and didactic materials used in cross-curricular investigation of digital education

Inverted classroom educational methodology

In recent years, the flipped classroom has become one of emerging innovative pedagogie in education . The Greek Minister of Education has already announced that from the academic year 2021-22 this pedagogical method will be applied in all schools in the country.The flipped classroom is an approach to teaching and learning activities where students watch a video lesson outside the class through distance learning and have hands-on activities in the class. So student is put at the center of the learning process, the frontal traditional teaching moves from the group learning space to the individual learning space and ensures an effective, active and interactive learning with changing environment, with activities and practices implemented as well as outside the classroom (Ayçiçek & Yanpar Yelken, 2018; Bergmann & Sams, 2014). In addition, the value of an inverted learning approach is that it ensures flexible and targeted management of the use of teaching time, so that students interact in the classroom with practical activities and application of content knowledge learned outside the classroom (Ozdamli & Asiksoy, 2016; Hadman , et.al, 2013).

The study of flipped classrooms was based on the **theory of Bloom's revised taxonomy** of cognitive domain. This taxonomy provides six levels of learning. The explanation is arranged from the lowest level to the highest level:

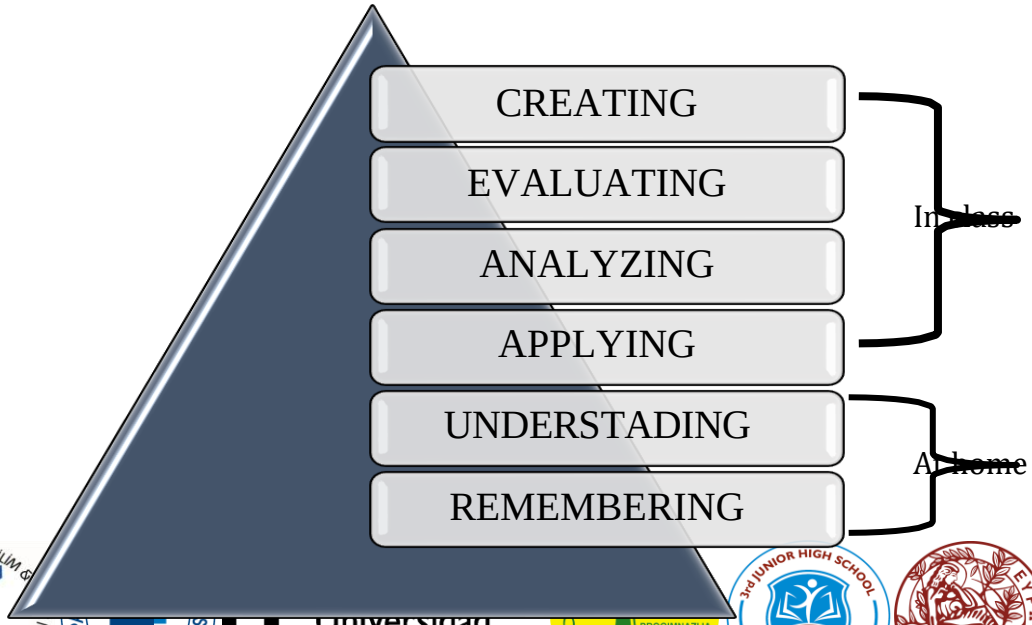


Figure 1.

Bloom's Revised Taxonomy in The Flipped Classroom

Remembering: in this stage, the students try to recognize and recall the information they receive; they also try to understand the basic concepts and principles of the content they have learned

Understanding: the students try to demonstrate their understanding, interpret the information and summarize what they have learned.

Applying: the students practice what they have learned or apply knowledge to the actual situation.

Analyzing: the students use their critical thinking in solving the problem, debate with friends, compare the answer with peers, and produce a summary. The students obtain new knowledge and ideas after implementing critical thinking or a debate in group activities. In this level of learning, the students also produce creative thinking.

Evaluating: assessment or established peer-review knowledge, judge in relational terms; in this stage, students are evaluating the whole learning concepts and they could evaluate or make judgment on how far they successfully learned.

Creating: the students are able to design, construct and produce something new from what they have learned (Bloom, 1969).

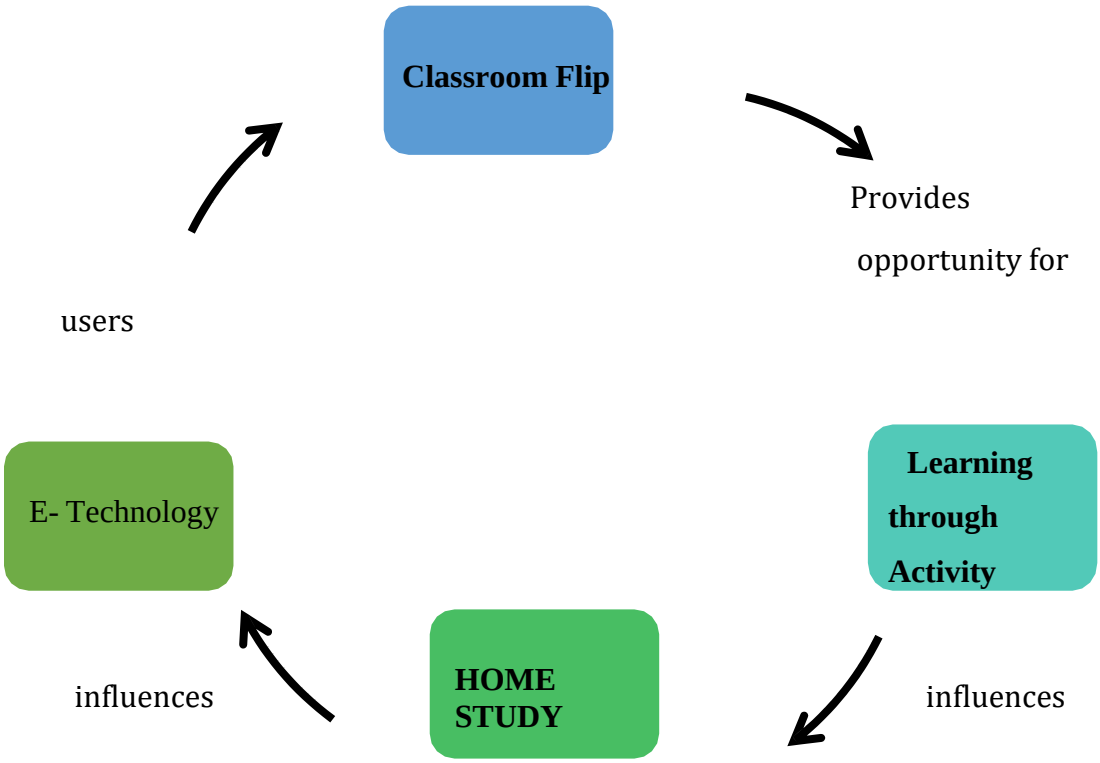
Understanding: the students try to demonstrate their understanding, interpret the information and summarize what they have learned.

Applying: the students practice what they have learned or apply knowledge to the actual situation.

Analyzing: the students use their critical thinking in solving the problem, debate with friends, compare the answer with peers, and produce a summary. The students obtain new knowledge and ideas after implementing critical thinking or a debate in group activities. In this level of learning, the students also produce creative thinking.

Evaluating: assessment or established peer-review knowledge, judge in relational terms; in this stage, students are evaluating the whole learning concepts and they could evaluate or make judgment on how far they successfully learned.

Creating: the students are able to design, construct and produce something new from what they have learned (Bloom, 1969).



Teaching standards

1. Set high expectations which inspire, motivate and challenge pupils.
2. Promote good progress and outcomes by pupils.
3. Demonstrate good subject and curriculum knowledge.
4. Adapt teaching to respond to the strengths and needs of all pupils.
5. Make accurate and productive use of assessment.
6. Manage behaviour effectively to ensure a good and safe learning environment.

7.13. Detailed needs of the organisations/ entities/institutions/schools in Greece in the field of STEM education with regard to the digital contents into the school curriculum in full compliance with the distance learning and teaching

Effective digital capacity planning and development is vital for education and training systems. This requires the development and ongoing review and updating of digital strategies addressing technology gaps in infrastructure, devices and developing relevant organisational capabilities in education, including the capacity to deliver hybrid modes of learning and teaching (remote and on-site). **Capacity should be developed to ensure accessibility to assistive technologies and accessible digital content and more generally address unequal access, e.g. on socio-economic or rural-urban grounds.** Institutionalised support is essential for such planning and development, as are interdisciplinary teams including management, technologists and instructional designers, with the needs and experience of education and training staff at the centre.

Very high-capacity internet connectivity is critical for education. **Demand for connectivity is increasing due to bandwidth-heavy applications** such as video streaming, video conferencing, cloud computing, and other emerging applications (such as virtual and augmented reality). **Bringing fast and reliable internet to educational institutions and learners plays an important role in ensuring effective and engaging learning experiences.** This means ensuring that internet access is not confined to a specific classroom or computer lab. **Moreover, educators consider reliable Wi-Fi access** as a pre-requisite if they are to use technology with confidence in their teaching. The recent period of educational disruption and closure of physical sites has underlined the need for learners to be able to access devices and the internet to continue with their learning at home or in other settings.

Educators should be empowered to adopt innovative methods; have the awareness of environmental and climate impact of digital technologies and services to make most sustainable choices collaborate; engage in peer learning and share their experiences. A trusted digital education ecosystem requires high-quality content, user-friendly tools, value-adding services and **secure platforms that maintain privacy and uphold ethical standards.** Accessibility, inclusiveness and learner-centred design are vital. The development of European digital educational content should **promote the highest pedagogical and educational quality and respect the diversity and cultural richness** of the Member States.

Digital literacy has become essential for everyday life. A sound understanding of digital information, including personal data, is vital to navigate a world increasingly infused with algorithms. Education should more actively help learners to develop the ability to critically approach, filter and assess information, notably to identify disinformation and to manage overload of information as well as develop financial literacy.

Countering disinformation and harmful speech through education and training is crucial for effective participation in society and democratic processes, especially by young people. More than 40% of young people consider that critical thinking, media and democracy are not 'taught sufficiently' in school

Computing education 22 in schools allows young people to gain a sound understanding of the digital world. Introducing pupils to computing from an early age, through innovative and motivating approaches to teaching, in both formal and non-formal settings, can help develop skills in problem-solving, creativity and collaboration. It can also foster interest in STEM-related studies and future careers while tackling gender stereotypes. Efforts to tackle gender stereotypes and gender bias in the digital sector are also much needed for improved gender balance in the sector. Initiatives such as the 'Women in Digital' strategy and WeGate 30 already work towards achieving these objectives but efforts need to be stepped up in order to make more progress.

Actions to promote high quality and inclusive computing education can also impact positively on the number of girls pursuing IT-related studies in higher education and, further on, working in the digital sector or digital jobs in other economic sectors.

Efforts to improve computing education in schools require a partnership approach, involving higher education, non-formal education, including libraries, Makerspaces and Fablabs 24 , as well and industry and education research. EU Code Week 25 , which grows year on year, is an excellent initiative to introduce a wide and diverse audience to coding, programming and digital creativity more widely.

Europe faces shortages of digital experts, including data analysts, cybersecurity analysts, software developers, digital accessibility specialists and machine-learning experts.

More needs to be done to promote professions and careers in the digital sector.

To understand the applications and implications of AI (Artificial Intelligence) for education, both educators and students need new skills, including basic AI and data literacy skills.

Improve monitoring and support the cross-national collection of data on student digital skills through participation in the ICILS to better understand gaps and strengthen the evidence base for actions to address these gaps. This will include introducing an EU target for student digital competence to reduce the share of 13-14 year old students who underperform in computer and information literacy to under 15% by 2030.

A good idea is to develop a European Digital Skills Certificate (EDSC) that may be recognised and accepted by governments, employers and other stakeholders across Europe. This would allow Europeans to indicate their level of digital competences, corresponding to the Digital Competence Framework proficiency levels.

DIGITAL TOOLS

Gigabit connectivity of schools, as well as connectivity in schools under the Connecting Europe Facility Programme.

Connectivity4Schools awareness raising actions on funding opportunities.

European Connect : broadband in investment and reform projects in national recovery and resilience plans under the Recovery and Resilience Facility.

SELFIE for Teachers : an online self-assessment tool for teachers, to help identify strengths and gaps in their digital, technical and teaching skills.

Horizon Europe : To promote understanding of emerging technologies and their applications in education, develop ethical guidelines on artificial intelligence (AI) and data usage in teaching and learning for educators and support related research and innovation activities.

WEgate : an online platform that aims to help women entrepreneurs to start build up their business with the help of engaging community and knowledge sharing.

ICILS :was designed to respond to a question of critical interest today: How well are students prepared for study, work, and life in a digital world? The study measures international differences in students' computer and information literacy (CIL). This type of literacy refers to students' ability to use computers to investigate, create, and communicate in order to participate effectively at home, at school, in the workplace, and in the community.

CHOICE: Increasing young people's motivation to choose STEM careers through an Innovative Cross-disciplinary STE(A)M approach to education

STEAMonEdu aims to increase the adoption and impact of STE(A)M education by investing in the community of stakeholders and the professional development of teachers

ESCO: (European Multilingual Classification of Skills, Abilities, Qualifications and Occupations)

MOOC : consisting of Open Educational Resources (OERs), aiming to enhance their professional skills teachers to be able to take advantage of the STE(A)M educational approach.https://mooc.edu.gr/courses

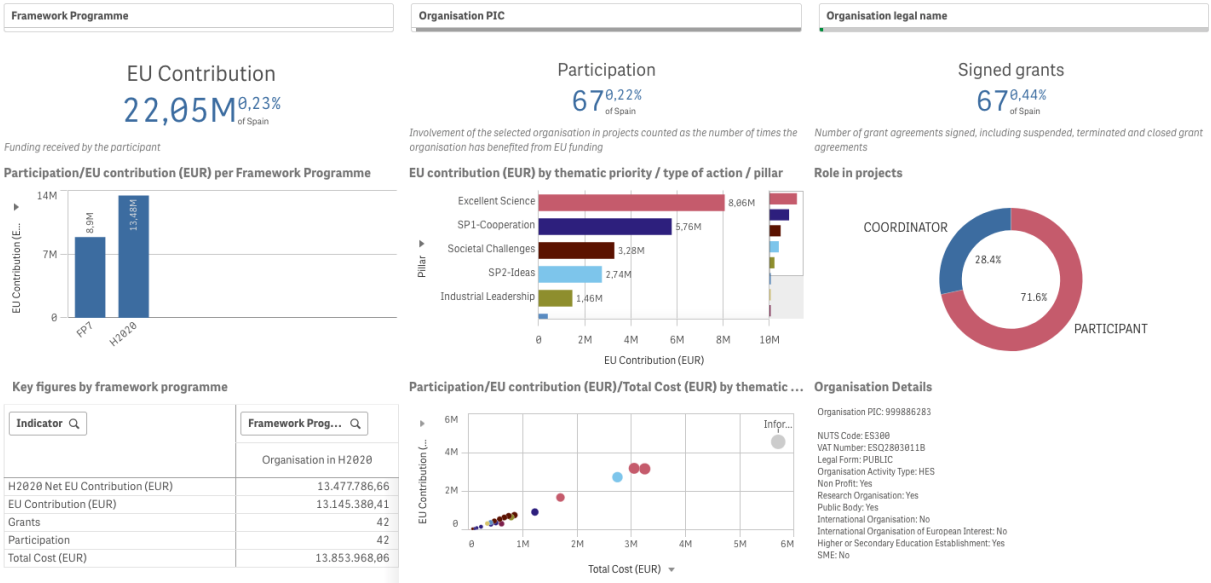
8. Spain

8.1. Universidad Rey Juan Carlos

Universidad Rey Juan Carlos (URJC) is the youngest and most modern of all public universities in Madrid. It has five campuses located in Móstoles, Alcorcón, Aranjuez, Fuenlabrada and Vicálvaro (Madrid), as well as two other locations in the the city center. It was created in 1996 with the objective of offering all-round preparation for its students, combining theoretical teaching with training in laboratories, companies and educational institutions, thus facilitating rapid access to the labour market. The university has, at present academic year 2018-19, 40.717 students enrolled, including 3.074 international students from all over the world, and a staff of more than 3.242 members, including both teachers and administrative personnel during the academic year 2020-21 (see https://www.urjc.es/ for more information). URJC promotes research aimed at economic, educational and social development that enhances the dissemination and transfer of knowledge to society. The promotion of Research and Technological Development (RTD) activities is carried out through collaboration with national and international companies and institutions to advance in science and technology endeavours. During the last decade, the URJC has increased the number of research proposals approved and funded, being significant the growth in the number of RTD projects in which URJC has participated and coordinated. URJC has been involved in 73 European projects (see https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/how-to-participate/org-details/999886283 for projects list) with a total of EU funding up to about € 22 M (including Starting Grants, Consolidator Grants and Proofs of Concept from ERC), of which 41 belong to the H2020 Programme. URJC has also actively participated in the Marie Sklodoswska Curie Actions, both acting as hosting institution for researchers, and participating in Individual Fellowships actions. Furthermore, URJC has coordinated a total of 21 projects (see https://webgate.ec.europa.eu/dashboard/single/?appid=a22d6695-65d1-4f7a-a06f-b5bf3f3cc59c&sheet=3bcd6df0-d32a-4593-b4fa-

0f9529c8ffb0&opt=ctxmenu,currsel&select=$::Organisation%20Name,UNIVERSIDAD%20REY%20JUAN%20CARLOS).

Figure 1. URJC'S projects at European Commission's Funding and Tenders Portal.



8.2. Previous experience with STEM education - projects, workshops

URJC has the following experience with STEM education projects, seminars, workshops and conferences:

I. "**Improving Math Achievement of Madrid Students**" is an international collaborative research project, which took place from June 2015 to June 2017, between the Institute for Learning & Brain Sciences (University of Washington) and Universidad Rey Juan Carlos (Spain). This project evaluated the usefulness of specific intervention strategies for reducing stereotypes and increasing identification with math in preschool children and elementary-school students from Madrid (Spain). This research project also assessed math-gender stereotypes, math self-concepts and math attitudes using both implicit and explicit measures to seek how to boost interest and achievement in STEM starting from early childhood and primary education.

***For more information on the project results you may check (a) Cvencek, D., Paz-Albo, J., Master, A., Herranz, C. V., Hervás, A., & Meltzoff, A. N. (2020). Math is for me: A field intervention to strengthen math self-concepts in Spanish-speaking 3rd grade children. *Frontiers in Psychology, 11*, 593995. https://doi.org/10.3389/fpsyg.2020.593995 and (b) Paz-Albo, J., Cvencek, D., Herranz, C. V., Hervás, A., & Meltzoff, A. N. (2017). Preschoolers' mathematical play and colour preferences: a new window into the development of gendered beliefs about math. *Early Child Development and Care, 187*(8), 1273-1283. https://doi.org/10.1080/03004430.2017.1295234

II. **"MiniOpenLab – Open Community and Hands-on Approach to Sustainable Development and STEM Education"** is an Erasmus+ KA2 *Cooperation for Innovation and the Exchange of Good Practices* project (KA201- *Strategic Partnerships for School Education, 2*020-1-ES01-KA201-082706) which takes place between September 2020 and August 2023 (36 months) and is co-funded by the Erasmus+ programme. The aim of this project is to develop and test methodologies with a prevalence of experiential learning by collaborating with science and technological organizations, companies and society in general. The main goal of this project is to use an hands-on approach to Sustainable Development and STEM education for children ages 6 to 12 years old, and comprises of (1) the creation of community small laboratories ("MiniOpenLabs") to engage children in STEM-based projects on sustainable development, (2) the design of an activity book with project-based activities for STEM, (3) the planning of workshops to involve the local community in STEM education activities in addition to (4) having a contest to recognize innovative practices in STEM education. This project brings together educational institutions from Portugal (Centre of Engineering and Product Development; Scholé), Greece (University of Western Macedonia; Antatolia Educational Group) and Spain (CEIPSO Maestro Rodrigo; Universidad Rey Juan Carlos).

***For more information on the "MiniOpenLabs" see: https://miniopenlabstem.com/

III. **"Stemind for Education"** is a R&D project funded by the *Agencia Estatal de Investigación (AEI)* under the *National Plan for Scientific and Technical Research and Innovation* in Spain (*Europe Research Dynamization Actions 2020*). This project takes place between November 2020 and October 2022 (24 months) in transnational collaboration led by a URJC research group. The main objective is to promote STEM research networks, establishing relationships among European higher educational institutions of higher education with outstanding research in the STEM field.

IV. **"Formación en materias STEM para futuros maestros"** is an 8-hour STEM education workshop designed for training future teachers in STEM subjects. It took place on March 12, 2020 and it was mainly designed for undergraduate students from the Degrees in Primary and Pre-Primary Education at URJC, although all the educational community could benefit from it. It pretended to raise awareness of the importance of deepening both theoretical knowledge and STEM didactic methodologies to enhance the teaching-learning process and inspire girls to take an interest in science and technology.

***For more information see: https://eventos.urjc.es/48881/detail/jornada-educacion-stem.html

V. **"Educación STEM para profesores"** is a 4-hour STEM education workshop designed for training in STEM education for teachers. It took place on March 11, 2021 and it was mainly designed for graduate students from the MA in Secondary Education at URJC.

***For more information see: https://miniopenlabstem.com/2021/03/10/training-in-stem-education-for-teachers-march-11th-urjc/

VI. **"STEM Talent Girl"** is an innovative training program designed to foster girls' vocation for science and technology, coordinated by the ASTI Foundation.

***For more information see: https://talent-girl.com/ and https://www.urjc.es/todas-las-noticias-de-actualidad-cientifica/4778-la-urjc-acogera-el-acto-inaugural-del-proyecto-stem-talent-girl-madrid

VII. **"VI Jornadas de Mujeres en Ciencia e Ingeniería**" is a workshop about women in science and engineering that highlights the importance of participation in STEM fields. It took place on June 24, 2021.

***For more information see: https://www.urjc.es/todas-las-noticias-de-actualidad/6496-la-urjc-pone-en-valor-la-presencia-de-las-mujeres-en-ciencia-e-ingenieria

VIII. **"Liderazgo de las mujeres STEM"** is a seminar that aims to encourage training in STEM disciplines among young women. It took place on October 10, 2019.

***For more information see: https://www.urjc.es/zh/todas-las-noticias-de-actualidad/4530-la-mujer-y-las-stem-protagonistas-en-el-campus-de-madrid

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8.3. Previous experience with STEM education - in everyday education

Our previous experience with STEM education in everyday education at Universidad Rey Juan Carlos can be observed in many of the curriculum courses taught at the undergraduate and graduate level. Our university offers degrees in Biology, Food Science and Technology, Environmental Sciences, Experimental Sciences, Math, Video Game Design, Aerospace Engineering, Computer Engineering among other degrees (see https://www.urjc.es/estudios/grado#ingenieria-y-arquitectura for the Engineering and Architecture degrees; see https://www.urjc.es/estudios/grado#ciencias for the Sciences degrees). STEM education is also embedded in our education degrees (see https://www.urjc.es/estudios/grado#ciencias-sociales-y-juridicas for the Social and Legal Sciences degrees). In our Degrees in Early Childhood Education and Primary Education there are STEM subjects related such as "Mathematics didactics", "Mathematical games laboratory", "ICT in education", "Educational research methodology", "Computer science and digital teaching competence" and "Social and experimental sciences" that specifically promotes the teaching and learning of STEM.

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At the graduate level, STEM education is embedded in master's degrees in the areas of Engineering and Architecture

(see https://www.urjc.es/estudios/master#ingenieria-y-arquitectura),

Sciences

(see https://www.urjc.es/estudios/master#ciencias), and

Social and Legal Sciences

(see https://www.urjc.es/estudios/master#ciencias-sociales-y-juridicas).

For example, in our Master's Degree in Teacher Training for Secondary Education students take courses on educational innovation and ICTs applied to the teaching of several fields such as social sciences, English language, mathematics, educational guidance, economics and business administration, tourism sciences, physical education, Spanish language and literature, biology and geology, audiovisual communication, computer science and technology, and physics and chemistry among others (see https://www.urjc.es/estudios/master/847-formacion-del-profesorado-de-ed-secundaria-bachillerato-fp-e-idiomas).

Our graduate students may also choose to specialize in STEM related areas and some students are introduced to the term STEM and are encouraged to integrate the different disciplines as prospective teachers in their future. For example, in the graduate course "Mathematics Didactics" students use a Problem and Project Based Learning (PBL) approach to integrate different STEM disciplines, and this PBL are transferred to secondary education institutions when they do their student placements. In addition, this PBL approach is also used in the teaching of STEM related areas in courses such as "Social and experimental sciences" in the Degree in Primary Education.

8.4. Participation in project Innovative Schools Teaching&Learning in DIGITAL STEM LABS

This project gives visibility to those initiatives related to the promotion of scientific, technological, engineering and math vocations among students by providing them with an enhanced provision of STEM education. Our institution is involved in training future early childhood, primary and secondary education teachers in STEM related areas and professors have a broad training in those areas. In addition, college students and professors at Universidad Rey Juan Carlos (URJC) seem interested in integrating digital contents into the curriculum due to a more distance learning and teaching approach since the beginning of the COVID-19 pandemic. However, there are still some professors who face several technology challenges to teach in a hybrid learning model.

Since there is a wide demand for professionals related to the STEM field in Spain, participating in the project *"Innovative Schools: Teaching & Learning in Digital STEM Labs"* will allow URJC to further promote STEM education at the local, national and international level. Our group consists of researchers with extensive training and knowledge in school organization, innovation, technology, languages and math education and who are responsible for the training of k-12 and secondary teachers, allowing a wider integration of digital contents into the curriculum in full compliance with the distance learning and teaching scenarios. This project will also have an impact on the improvement of future school teachers training in the development of digital teaching methodologies. Our prospective secondary educators do their field practice during their junior and senior years so their participation in this project will allow them to observe how STEM education is embedded in the curriculum as well.

This project will also allow our institution to promote networking with other institutions sharing resources and collaborating with digital technology providers in educational technologies to overcome digital STEM challenges, and thus reflect on previous collaborations regarding the use of Innovation and Communications Technologies (ICTs) in education (see https://grupoimei.weebly.com/projects.html and https://www.rtve.es/play/videos/la-aventura-del-saber/aventurablklearning/4443388/), and see what works in STEM education. Specifically, our *Innovation and Educational Improvement Research Group* at URJC has experts in pedagogical practices, educational technologies that can help us to implement methodologies and integrate digital contents into the curriculum.

8.5. Relevant policy frameworks in the field of valorisation and interpretation and appropriate presentation of STEM education in Spain

There is a wide demand for programs that promote measures for STEM skills' development from the early years in schooling. In Spain, digital competence is part of the curriculum of compulsory education and considered a key competence to be developed in primary, secondary education and beyond. The recommendation focus is on initiatives and actions needed to strengthen key competences as the European Commission suggests (see https://data.consilium.europa.eu/doc/document/ST-5464-2018-ADD-2/EN/pdf) since it calls for more prominence to STEM-related competences and foster the acquisition of competences in STEM to increase the level of digital competences.

The new Organic Act Amending the Organic Law of Education, known as the LOMLOE education law (see https://www.boe.es/eli/es/lo/2020/12/29/3) was approved at the end of 2020 and sets a new framework in the field of STEM education in Spain. The development of this new curriculum model requires students to acquire and develop eight competences before the end of compulsory education, being *"mathematical, science and technology competence"* and *"digital competence"* two among those competences. Although these competences come from the Sustainable Development Goals of the 2030 Agenda and the Recommendation of the Council of the European Union of 2018, the Spanish education system is trying to increase STEM vocations, especially among female students.

The acquisition of technological competence with a critical view is one of the objectives for the Primary Education level, encouraging students to develop a scientific spirit and focusing on competence learning and the promotion of ICTs. Secondary Education promotes competency-based learning with a special focus on technological and digital competences and offers a *"Sciences and Technology"* modality for high school students (see https://eacea.ec.europa.eu/national-policies/eurydice/content/national-reforms-school-education-70_en). On the other hand, a *Common Digital Competence Framework for Teachers* was created in 2020 (see https://www.boe.es/diario_boe/txt.php?id=BOE-A-2020-7775), an adaptation from the *European Digital Competence Framework for Educators* and the *European Digital Competence Framework for Citizens*. This framework will be used to design educational policies in Spain to improve the digital competence of educators, and it will contribute to the development of students' digital competences (see https://intef.es/formacion-y-colaboracion/competencia-digital-educativa/).

8.6. Relevant good practices and case studies in the field of valorisation and interpretation of STEM education in Spain in formal and informal education

In Spain, the Ministry of Education and Vocational Training (*Ministerio de Educación y Formación Profesional*, MEFP) is interested in promoting more scientific vocations in young people and especially for girls

(see:https://www.educacionyfp.gob.es/prensa/actualidad/2021/02/110221-alianzasteam.html). They have implemented several initiatives in the last few years and have recently launched a "STEAM Alliance" to promote STEAM vocations from the early years in order to reduce the gender gap

(see:https://www.educacionyfp.gob.es/dam/jcr:4872de02-88c3-42b9-af7e-2eb25c15b681/listado-steam.pdf for a complete list of the 49 participating entities). Moreover, the National Institute of Educational Technologies and Teacher Training (*Instituto Nacional de Tecnologías Educativas y Formación del Profesorado*, INTEF) has created the "ChicaSTEM" (GirlSTEM) project that highlights the importance of incorporating girls into STEM related studies, not only to achieve effective equality in studies and professions, but to enrich technological projects with other perspectives as well.

There are national initiatives (https://code.intef.es/iniciativas/iniciativas-nacionales) and ongoing projects being developed in several Autonomous Communities in Spain, such as *"Planeta STEM"*

(https://www.pamplonetario.org/es/planeta-stem),

"Inspira STEAM" (https://inspirasteam.net),

"Quiero ser ingeniera" (https://quieroseringeniera.upct.es),

"Mujeres, Ciencia y Tecnología"

(http://www.juntadeandalucia.es/iamindex.php/areas-tematicas-coeducacion/curso-2018-2019/mujeres-ciencia-y-tecnologia),

or *"STEMadrid"*, an educational project that involves 28 educational institutions in the Autonomous Community of Madrid to consolidate STEM methodologies and teacher training (https://www.comunidad.madrid/servicios/educacion/es-stemadrid). These *STEMadrid schools* develop their own educational plans to promote STEM vocations including: (1) specific measures aimed at promoting scientific-technological vocations among female students, (2) methodological proposals to improve the mathematics teaching-learning process, (3) initiatives to enhance the knowledge of English for science and technology, and (4) STEM activities to engage the educational community and families.

There are also social projects such as Escuelab (see https://www.escuelab.es/) that promotes practical and interactive science education, fostering scientific vocations and developing STEM skills in children ages 3-14 years via a variety of extracurricular activities, workshops, or even STEM camps. In addition, the Ministry of Education organizes "Scientific Summer Camps" for secondary school age students that take place in Spanish universities in collaboration with secondary school teachers to be involved in scientific projects for a week (see https://www.fecyt.es/es/recurso/campus-cientificos-de-verano for more information).

8.7. Examples of educational provision about STEM education at the secondary education level, including higher educational programs

There are currently several programs at the primary and secondary education to promote STEM skills throughout Spain. However, each Spanish educational system is a decentralized system, meaning that each Autonomous Community has the autonomy to decide which educational provisions to implement. At the higher education level, Spanish universities also offer STEM related courses in some of these areas for training future Early Childhood, Primary (see *STEM Education and Primary Teacher Training in Spain*

https://sede.educacion.gob.es/publiventa/d/25264/19/)and Secondary teachers.

At the national level the 2020 Organic Act Amending the Organic Law of Education, known as the LOMLOE education law

(see https://www.boe.es/eli/es/lo/2020/12/29/3) sets a new primary and secondary school framework in the field of STEM education in Spain. The development of this new curriculum model requires students to acquire and develop STEM competence in addition to the other seven competences. In this way, the STEM educational approach is integrated into the new Spanish competency-based curriculum, allowing students to understand the world using the scientific method, mathematical thinking and representation, technology and engineering methods to transform the environment in a responsible and sustainable way. Although it may be challenging some Autonomous Communities have promoted initiatives to reinforce the possibilities of this STEM educational approach.

For example, in Galicia they have designed spaces to foster a STEM approach and promote collaborative work. They have also created an active STEM education that takes place in a specialized STEM room known as "Newton Galicia Room" and offers education within science, technology, engineering and mathematics, mainly for students ages 14-16 years in the municipality. The curriculum is based on learning through practical activities (see https://newtonroom.com/es/localiza-tu-aula-newton/newton-galicia). They also promote other STEM activities aimed at young people from Galicia with the main goal of promoting scientific vocations: Galiciencia, Aulas Tecnópole, STEAM Kids Tecnópole, T2W and Ciencia y Tecnología en femenino

(see https://newtonroom.com/es/localiza-tu-aula-newton/newton-galicia/aboutus for more information on each of these activities). *The "Science and Technology in Feminine"* is a project in which students ages 11-13 years attend a series of workshops in 19 Science and Technology Parks (see Figure 2) around Spain (see https://www.apte.org/science-technology-in-feminine for some examples) to promote scientific and technological vocations, especially among young girls. In Spain, a total of 22 of these Science and Technology Parks are sponsored by universities and 44 Spanish universities collaborated with them.

Figure 2. *Spanish Science and Technology Parks*

8.8. Best practice curricular/methodological models for the integration of STEM skills in general education subjects at the lower/upper-secondary level that exist in Spain, practical teaching/ learning arrangement in distance education

The Spanish Baccalaureate (upper secondary education) is structured intro three branches (Sciences, Humanities and Social Sciences, and Arts) and lasts for two academic years. Its curriculum establishes the "mathematical competence and basic competences in science and technology" as one of the key competences to develop during the secondary school years (see https://eacea.ec.europa.eu/national-policies/eurydice/content/teaching-and-learning-general-upper-secondary-education-58_en for a summary of the structure of the secondary education level in Spain including the curriculum, subjects, number of hours, teaching methods, as well as the curricular materials, teaching resources and the role of ICTs in the curriculum).

In Spain, the *general principles* which must guide the teaching practices at the secondary level are established by the Spanish Ministry of Education and Vocational Training at the State level

(see https://eacea.ec.europa.eu/national-policies/eurydice/content/teaching-and-learning-general-upper-secondary-education-58_en). In addition, education authorities formulate a series of methodological principles that schools implement in their classrooms although each school define their teaching methods. However, schools enjoy pedagogic autonomy, and they decide on curricular materials, teaching resources and methodological approaches adapted to their students.

Over the last decade, a pedagogical innovation movement has re-emerged in the educational field in Spain, driven by the concerns of teachers and educational institutions to offer more effective teaching learning practices and learning environments, leading to activities and methodologies such as Flipped Classroom, Cooperative Learning, Thinking Based Learning, Gamification Based Learning, Competency Based Learning, or Project Based Learning (PBL) approaches to develop mastery of skills and content (see https://webdelmaestrocmf.com/portal/8-metodologias-profesor-deberia-conocer-ahora for an introduction to 22 innovation methodologies). Some schools also embedded *eTwinning* in the curriculum as a PBL approach. There are currently 17.146 eTwinning schools in Spain and some of them have integrated STEM skills in the creation of these projects (see http://etwinning.es/es/etwinning-y-stem/ for examples of STEM Spanish eTwinning projects). However, there is a need to identify criteria and guidelines that allow the selection and design of quality STEM projects. Some of the teaching and learning arrangements in distance education during the COVID-19 pandemic aim at supporting and mitigating the consequences of the closure of schools in Spain. For example, ProFuturo's digital learning platform was opened to teachers and students providing them with a more personalized learning environment and methodologies which has been adapted to reach students with no access to internet (see Spain: #SeeYouInDigital (Ensuring the continuity of learning) for more information). However, keeping interpersonal distance have discouraged the use of these active methodologies and an increased awareness about the value of ICTs for education have been supported in Spain. The National Institute of Educational Technologies and Teacher Training (*Instituto Nacional de Tecnologías Educativas y de Formación del Profesorado*, INTEF) also promotes methodology changes in the Spanish classrooms and focus on educational resources that both educators and students can use in and outside of their schools. In fact, some of these resources aim at supporting STEM learning opportunities in primary and secondary education (see https://code.intef.es/ for

educational technologies, https://intef.es/recursos-educativos/ for learning resources and https://intef.es/formacion-y-colaboracion/ for online learning and collaboration projects).

8.9. Possibilities and recommendations for the integration of STEM fields into the secondary school curriculum

According to the STEMadrid (http://educacionstem.educa.madrid.org/), it is essential to promote the curiosity of students so they can be engaged in STEM activities. In fact, the main characteristic of STEM education is that it is based on practice. Experience replaces passive and rote learning in such a way that the same concept is offered in different contexts, so that students can create connections between different disciplines through their own experience. In addition, a wider integration of the STEM fields in the secondary school curriculum from the curricular reform launch in the participating countries will provide schools a context to examine and apply knowledge to improve their problem-thinking skills, as well as to develop creativity, curiosity and teamwork.

The foundation of our STEM learning framework will increase our students' and teachers' STEM skills and knowledge through a range of activities applied into authentic contexts. However, the social aspect of these learning activities is also critical to the STEM learning process (see https://telrp.springeropen.com/articles/10.1186/s41039-019-0119-y for a study on the use of learning strategies and functional tools in STEM education). In fact, collaboration for STEM problem solving provides benefits and improve learning effectiveness since it will equip our students with anticipated skill sets for the future.

A wider integration of the STEM fields into the secondary curriculum will also inspire the pursuit of further STEM education among students. Moreover, our proposed curricular reform will allow to bring real STEM to life in our classrooms by using best practice STEM teaching methods. Our students will also be encouraged to understand digital technologies and the foundational skills required in an ever-changing working force by doing real science in the process in compliance with the distance teaching and learning policy for schools. The development and improvement of distance STEM teaching and learning is a strategic area that requires to improve the competencies of secondary school teachers for the development of digital methodologies in line with the new application of distance STEM education (innovations, smart specialization and design-based innovation).

Teachers need to devise ways to implement pedagogies, methodologies and ICTs that engage students and increase their participation in STEM fields and improve the quality of STEM projects. However, educators need to look for ways to teach through an integrated STEM approach using a STEM pedagogy (see the Journal of Research in STEM Education and *The Impact of Engagement in STEM Activities on Primary Pre-service Teachers' Conceptualization of STEM and Knowledge of STEM Pedagogy* for a review of studies on STEM pedagogy, integration and learning). It is essential to provide teachers training related to the design and implementation of STEM projects to maintain students' interest, implement the use of new technologies as they meet the continuous demand for higher educational standards.

8.10. Needs of organisations/ entities in Spain in the field of STEM education with regard to the adequate competencies of teachers in distance teaching/ learning

In relation to teachers' competence needs with respect to STEM education, we must take into consideration that teachers are not specialists in all areas. Nevertheless, they may acquire the necessary skills to get their students interested and motivated by learning in distance learning scenarios. For this purpose, the *Common Digital Framework for Teachers* in Spain was created since there is a "need for technology to be fully exploited and integrated effectively in training centers, as well as improving access to education through open educational resources and the unprecedented opportunities that new media offer for professional collaboration, problem-solving and quality improvement and equity in education" (Common Digital Framework for Teachers, p. 2).

This *Common Digital Framework for Teachers* is a reference framework for the diagnosis and improvement of the digital competences for teachers, adapted from the *European Digital Competence Framework for Citizens v.2.1* (DigComp) and the *European Digital Competence Framework for Educators* (DigCompEdu) and is divided into 5 competence areas (Information and data literacy, Communication and collaboration, Digital content creation, Safety, and Problem solving) in which 21 competences are defined in 6 proficiency levels (see https://aprende.intef.es/sites/default/files/2018-05/2017_1024-Common-Digital-Competence-Framework-For-Teachers.pdf for a detailed description of these competences). This framework is a digital tool used for the *Digital Competence Portfolio for Teachers,* but they must prepare students to live and work in a constantly changing environment.

Now that STEM teachers are engaged in some form of distance teaching and learning, they need to have not only tech skills, but a solid preparation and specialized pedagogical training applied to STEM fields. Teachers need to develop lessons plans designed for distance instruction and find creative ways to keep students engaged by learning new online tools and technologies. In addition, they need to innovate and create engaging STEM experiences for their students, but it takes more than creativity to teach in an online curriculum. Educators also need to develop (1) strong communications skills and (2) supportive personal qualities (see *9 Skills That Make a Great Online School Teacher*).

8.11. National strategies and current national curriculum in Spain with regard to STEM education concerning digital education readiness (using SWOT analysis)

The Spanish strategies related to the *Digital Competences of Educational Institutions* are aligned with the European DigCompOrg Framework and aim to develop guidelines that guide schools to become digitally competent educational organizations. For this purpose, online self-assessments tools such as the "Plan Digital de Centro" (Digital Centre Plan, PDC) are created to help schools to design a digital plan adapted to their own specific needs. The PDC is a resource that promotes and enhances the use of digital tools in the teaching learning process. In Spain, SWOT analysis is recommended for schools a strategic planning and management technique used to help schools identify strengths, weaknesses, opportunities, and threats. For this purpose, the National Institute of Educational Technologies and Teacher Training (INTEF) recommends schools the use of the European tool SELFIE (Self-reflection on Effective Learning by Fostering the use of Innovative Educational technologies) to analyse whether they are making the most of digital technologies for teaching and learning, what changes might be needed and formulate action plans accordingly. In fact, SELFIE involves teachers, school leaders and students to reflect on technology use so they can make informed decisions about how digital technologies are used to support the teaching and learning process in their own schools. In this regard, the 2021 Spanish Ministry of Education study *"La capacidad digital de los centros educativos españoles"* (see https://intef.es/Noticias/estudio-la-capacidad-digital-de-los-centros-educativos-espanoles/ for the full report) offers an overview of technology integration in Spanish primary and secondary schools using SELFIE and may serve as a reference for schools.

On the other hand, the Spanish educational system includes STEM education as one of its priorities. In fact, the new 2020 Spanish Education Act (known as LOMLOE) establishes a new curriculum based on 8 competences, two of them being "*Math and Science and Technology (STEM) Competence"* and *"Digital Competence"*. This Spanish *STEM Competence* involves understanding the world using the scientific method, mathematical thinking and representation, technology and engineering methods to transform the environment in a committed, responsible and sustainable way. The Spanish *Digital Competence* implies the safe, healthy, sustainable, critical and responsible use of digital technologies for learning, at work and for participating in society, as well as interacting with these technologies. At the regional level, autonomous regions such as Galicia have included STEM education guidelines into their initial teacher training programs (see the Scientix Observatory Report about education practices in Europe) and they have promoted initiatives to reinforce a STEM educational approach in education.

8.12. National strategies in the field of education, current national curriculum, and fields that (in)directly cover STEM education regarding teaching standards, innovative pedagogies and didactic materials used in cross-curricular investigation of digital education

The *Spanish Foundation for Science and Technology* (Fundación Española para la Ciencia y la Tecnología, FECYT) promote open and inclusive science, culture and scientific education, responding to the needs and challenges of the Spanish Science, Technology and Innovation System. They offer the educational community information on activities, projects, teaching resources, training among other initiatives to support STEM education in formal and informal settings. For example, they promote innovative pedagogies such as the "Journal Club", the "FameLab", the "Somos Científicos y Científicas" platform and the "Eu-Citizen Science" where students interact with scientists.

The new 2020 Spanish Education Act (known as LOMLOE) focuses on the importance of the development of students' digital competence in all educational stages, both through specific content and in a cross-curricular perspective and emphasizing the digital gender gap. Students need to develop digital competence and be equipped with the necessary competences to meet the demands of the digital societal change in a global world. In fact, the Spanish government have launched "Educa en Digital", an educational program to enhance the digital transformation of the educational system in Spain. This program implements digital platforms to support teachers, students and educational authorities and promote a more personalized education by establishing unique itineraries for each student. Therefore, teachers will be able to monitor and assess their students' individualized progress more effectively

(see https://www.educacionyfp.gob.es/en/prensa/actualidad/2020/06/20200616-educaendigital.html for more information).

Autonomous regions also adopt individual initiatives to promote the study of STEM fields. For example, the "Vivero STEMadrid" is a digital platform that offers STEM resources and educational programs to be used inside and outside the classroom in Madrid schools. In fact, the Madrid region has designed their own program to promote the study of STEM disciplines, enhancing curiosity and facilitating the learning process from the students' own experience. STEMadrid also intends to consolidate STEM methodologies and train educators to implement them in the classrooms *(see* https://www.comunidad.madrid/servicios/educacion/es-stemadrid for more information).

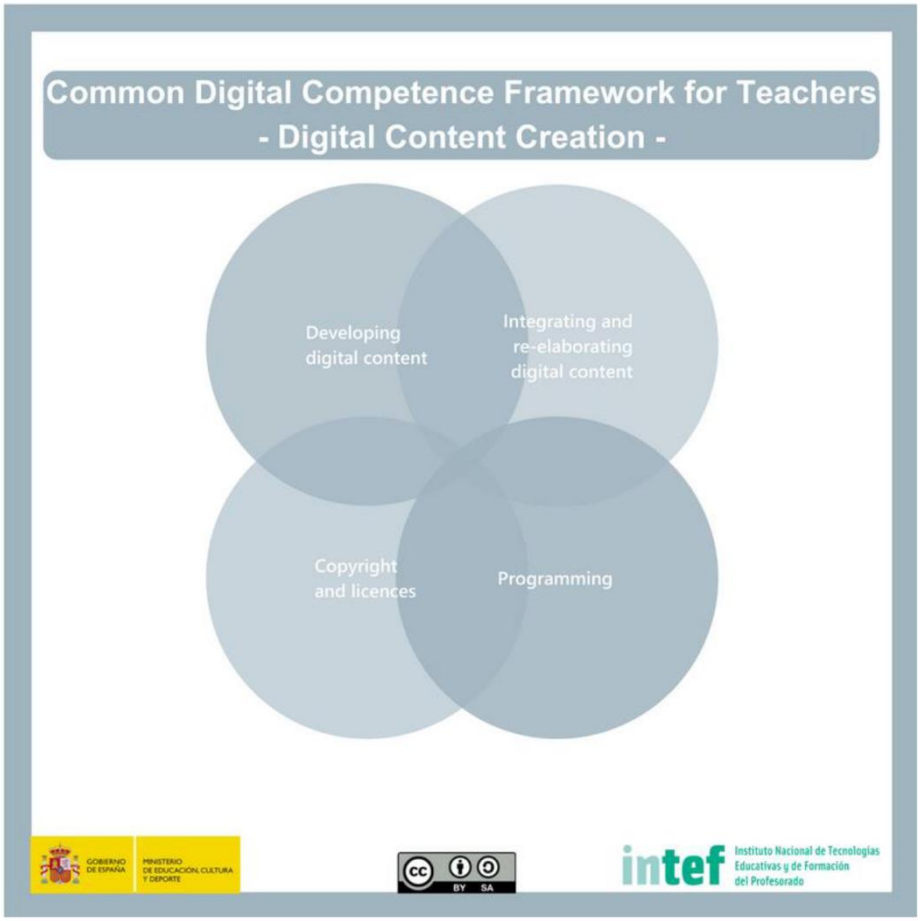
8.13. Detailed needs of the organisations/ entities/institutions/schools in Spain in the field of STEM education with regard to the digital contents into the school curriculum in full compliance with the distance learning and teaching

As the COVID-19 pandemic worsened in Spain, schools implemented different remote learning strategies to reach all students but were not always successful. However, as the *OECD Country Note* for Spain shows many schools were forced to come up with pragmatic and innovative solutions to prepare teachers, students and schools (see https://www.oecd.org/education/Spain-coronavirus-education-country-note.pdf for more information). Moreover, it seems that more schools are prepared for ICT-based learning but there is also a need for professional development in ICT skills for remote teaching and learning.

The implementation of digital contents into the school curriculum requires the ability of adequate resources for its access and use. In Spain, there is a need for STEM digital technology to be used with the distance learning and teaching scenario. However, companies such as Microsoft are committed to digital and STEM content to be implemented in classrooms (see https://www.microsoft.com/en-us/education/educators/stem for more information) and engage every student to help them develop their STEM skills. In fact, they are committed to the integration of digital content and the transformation of educational publishers to promote innovation and improve the quality of education in Spain, adapting it to the requirements of the digital age. Moreover, the National Institute of Educational Technologies and Teacher Training (*Instituto Nacional de Tecnologías Educativas y Formación del Profesorado*, INTEF) offers training, resources and programs to help classrooms' journeys into digital transformation of education. Additionally, some of the primary objectives of the Spanish education policy is a commitment to the digital competence of students and teachers, the curricula updating, the promotion of technological and scientific careers in female students and the improvement of the conditions for teaching.

On the other hand, a *Common Digital Competence Framework for Teachers* was created in 2020 (see https://www.boe.es/diario_boe/txt.php?id=BOE-A-2020-7775), and will be used to design educational policies in Spain to improve five areas of the digital competence of educators (see Figure 3 for the Digital content creation competence).

Figure 3. Digital content creation



http://aprende.intef.es/sites/default/files/2018-05/2017_1024-Common-Digital-Competence-Framework-For-Teachers.pdf

9. Lithuania

9.1. Panevezio "Zemynos" progimnazija

Panevezio "Zemynos" progymnasium is a constantly learning organization, equipped with the latest information and communication technologies. It is a safe and cosy oasis for the education of a young person, in which children acquire general subjects, socio-cultural literacy, moral, national and civic maturity, and are educated as Lithuanian citizens open to the world. Teachers work according to the principle "School for the student". They are open to innovation, communication and collaboration. Vision of Panevezio "Zemynos" progymnasium is that our school is a modern, open to change, harmonious, meaning and discovery, striving for personal education success, providing quality education according to the formal part of formal primary and basic education and non-formal children's swimming pool programs, basic humanistic values and community agreements a school that is based on its activities and is constantly learning.

Main aims of our school are:

- to develop the student's personality, his general and subject competencies necessary for further learning
- to help each student achieve personal and academic progress according to their abilities and needs.
- to form a curious, fully active, honest student, ready for a full personal and social life.

3 vice- principals, 50 teachers, 10 swimming coaches, 2 teaching assistants, and 7 educational support specialists work at Panevezio "Zemynos" progymnasium. Students are actively involved in school life. At school are established several youth organizations such as Ateitininkai, Kudirkaičiai, Scouts. Students participate in various city and republican educational and sports competitions.

The school has 38 classrooms, a library, a reading room, a craft workshop, a pottery studio, a science laboratory, information technology, dance and theater, educational support rooms, nurses, sports and gyms, a swimming pool, a sports ground and a canteen.

Students and other members of the community have access to wireless and wired Internet and e-mail in all classrooms, the library, the student reading room, study rooms, and the teachers 'room.

The school currently has 146 computers. The study rooms, reading room and assembly hall are equipped with: 41 multimedia projectors and 4 interactive appendices, 6 interactive whiteboards, 55 tablets.

Panevezio "Zemynos" progymnasium is participating in three ERASMUS+ plus projects:

- We are different, we are respectful, we are stronger with you: dyslexia. 2020-1-TR01-KA201-092954
- Innovative Schools: Teaching & Learning in DIGITAL STEM LABS 2020-1-TR01-KA226-SCH-097611
- "More mobile more successful" 2019-1-FR01-KA229-063021

9.2. Previous experience with STEM education - projects, workshops

Panevezys Zemynos progymnasium took part in The Leadership Time project which was a national initiative aimed at establishing a leadership-friendly environment in the Lithuanian education system, which would encourage school, municipal and national level educators to make progress in student education, initiate and implement qualitative changes in their organizations. The principal was a part of the creative team of the project. The school had a project implementation team as well.

The creative team of the Panevėžys city project had chosen to implement the theme of the change project - "Interinstitutional cooperation in developing experiential learning in STEAM subjects". The following activities were planned in the progymnasium during the implementation of this project:

- Lessons for grades 1-8 - practical activities in RoboLabe;
- Experiential activities in progymnasium, Panevėžys city and district enterprises, institutions;
- Experiential activities in progymnasium, Panevėžys city and district enterprises, institutions;
- Young Researchers' Day of non-traditional education;
- Consultations, internships in Lithuania and abroad, meetings with other school teams implementing this project;
- Seminar for the school community "Experiential learning", trainings "How to work with Newline";
- Sharing good work experience with teachers of progymnasium and Panevėžys city educational institutions during meetings, consultations, seminars, conferences.

9.3. Previous experience with STEM education - in everyday education

Applying STEM education, teachers collaborate, work in teams and organize integrated lessons in different subjects (science, IT, mathematics, arts, etc.) to explore different aspects of a chosen topic. The content of the lessons is linked to everyday experiences. Students gain knowledge by solving problems, preparing research projects, conducting case studies, collecting factual material at the research site, etc. Education is often transferred to non-traditional places, students travel to other cities, visit museums, exhibitions, natural objects, etc. There is a centre of robotics "Robolabas" in Panevežys, where teachers organize educational excursions. There is a new science laboratory in our school. The laboratory is used by students in grades 1-6 for various practical activities.

In the academic year 2021-2022, students in grades 1-4 participated in an educational program about snails and practically researched snails by growing them in the classrooms. They searched for the information on the Internet, prepared the material about snails and presented it in classrooms. Onions and beans were grown in the classrooms too. Students found out about the conditions necessary for the plant to grow, observed and recorded the process of the plant growth.

Year 8 students calculated the cost of a glass of different juices in the project "Financial Literacy". They squeezed the juice, calculated how many fruits are used to squeeze a glass of juice and the price of it. Students searched for information about the benefits of juice and presented it to the classmates.

Students worked with the Mind Designer program in the Robotics Centre "Robolabas". They learnt the names of Lithuania's neighboring countries, the names of geometric shapes and their parts, made TANGRAM pictures of geometric shapes on a tablet, and the robots drew their chosen picture.

In the school laboratory, students learnt how to estimate the solubility of substances, about weighing instruments and how to use them, carried out experiments with salt, made a souvenir, and learnt about the composition of soap and made it.

Students in grades 5-7 worked on the following topics: "Shopping with a percentage discount", "Ornaments made from the stamps obtained by dividing a circle into equals", "Spatial shapes around us. Box packaging.", "Direct proportionality in the kitchen. Food recipes", "Symmetry in Panevėžys' buildings", "Room renovation".

9.4. Participation in project Innovative Schools Teaching&Learning in DIGITAL STEM LABS

In the 21st century, scientific and technological innovations have become increasingly important as we face the benefits and challenges of both globalization and a knowledge-based economy. To succeed in this new information-based and highly technological society, students need to develop their capabilities in STEM to levels much beyond what was considered acceptable in the past. Thus, STEM education helps students to understand a wide range of concepts and thrive in many industries. So it is one of the main reason why tt is really crucial to take part in ERASMUS+ School Project 2020-1-TR01"-KA226-SCH-O976, INNOVATIVE SCHOOLS: TEACHING AND LEARNING IN DIGITAL STEM LABS because, STEM education makes natural sciences, technologies, engineering, mathematics more attractive and allows students to test the theoretical statements of these sciences in practice. Students' interest and involvement are increasing, general and subject competencies are being developed more successfully, and students' academic achievements are improving. It is expected that students experiencing STEM education are more likely to choose careers related to these sciences. Lessons with STEM education are more engaging, more interesting and more relevant to the problems being solved in the real world. Students see the meaning of learning and take an interest in these sciences, and the motivation for education increases. Furthermore, STEM Education is a critical component of a complete, quality education curriculum as we prepare today's students to become the innovators, entrepreneurs and job creators of tomorrow.

9.5. Relevant policy frameworks in the field of valorisation and interpretation and appropriate presentation of STEM education in Lithuania

In Lithuania strengthening Science, Technology, Engineering and Mathematics (STEM) education is recognized as embedding solutions to a huge number of societal problems like the depletion of natural resources and issues related to climate change. The recognition of STEM disciplines as economic drivers motivated the initiation of STEM education in both developed and developing nations. This is based on the thinking that an effective STEM education is a vehicle for developing in students the much-desired twenty-first century competences. Yet, its operationalization has remained a great challenge. In Lithuania, teachers lack a cohesive understanding of STEM education and are also deprived of an easy-to-understand STEM education framework that informs classroom practices. So, Lithuanian's Ministry of Education set up so-called STEM centres in order to boost school students' interest in natural science, engineering and mathematics. The interactive educational centres operate in Lithuanians' towns, allowing students to explore some of the developments in technology and scientific research and conduct their own experiments.

9.6. Relevant good practices and case studies in the field of valorisation and interpretation of STEM education in Lithuania in formal and informal education

STEM education is one of the most modern forms of education, integrating science, technology and engineering, arts and mathematics disciplines, linking them to the real world, change and progress, sustainable development goals, real-world problem-solving, forming students' critical thinking and problem-solving skills.

The integrated use of the principle of education in education can help to solve the problem of students' lack of interest in natural sciences and other STEM disciplines, to prepare future leaders. Based on the data, the Lithuanian employment service's Lithuanian employment trends and future forecasts made in 2018 envisage and name that in 2019. Some of the most in demand are engineering, mechanical, electronics, electrical, construction engineers, IT developers, programmers and systems analysts.

A network of STEM schools and open access centres is being established in Lithuania, where it is intended to acquaint students not only with the subtleties of those disciplines, but also to look at them creatively and interdisciplinary, connecting art and design. Methodological centres are established in the cities of Vilnius, Kaunas and Klaipėda, and regional centres in the territories of Alytus, Marijampolė, Panevėžys, Šiauliai, Tauragė, Telšiai and Utena counties. Their standardized and specialized laboratories are different. So, it means that each centre has a specific direction for teachers and students to go there and do activities of interest - be it mechatronics, marine research, or astrophysics, science.

STEM centres aim is:

- to encourage students to choose STEM studies,
- to supplement general education programs with their activities,
- to create modern and inspiring STEM learning environments,
- to improve teachers' competencies and qualifications,
- to provide students with professional guidance,
- to popularize STEM achievements,
- to help students' complete maturity work not only schools, but also in these centres.

9.7. Examples of educational provision about STEM education at the secondary education level, including higher educational programs

One of the STEAM breakthrough projects is the STEM School Label, a STEM School Label portal designed to help European schools strengthen and improve young people's capacity and interest in STEM, to provide schools with the necessary tools and methodological support to help students, the involvement of teachers and other stakeholders in STEM activities in the design and development of the STEM strategy. Seven intellectual products have been developed, all of which are openly available on the STEM School Brand Portal. Selected key elements that symbolize, reveal the STEM strategy, selected criteria for each element that show and evaluate STEM activities. Schools evaluate their STEM activities using the online criteria self-assessment tool and improve it according to the 21 criteria that define the STEM school, as the tool identifies areas for improvement, provides an action plan and resources. There are 7 key elements: training, professional development of staff, communication, adaptation of curricula, school infrastructure, management of the school and its culture, and evaluation. For each of these elements, criteria are provided for how they could contribute to the implementation of STEM activities. Any school wishing to self-evaluate its STEM strategy and be visible to other Lithuanian and world schools can register on this portal, as the portal is international. First, the school registers, presents its case studies, examples of good practice, shares experiences, sees the experiences of other participants, evaluates them, adapts them to its educational processes, participates in monthly surveys, provides evidence of school experience in forums, case studies and self-assessment questionnaires. He then receives feedback, finds out if all seven elements are strong, whether any of them need to be improved and how to do so (a consistent guide to school self-assessment is also provided on the portal). The STEM school - beginner, advanced or experienced - is awarded based on the number of points scored. Each badge can be improved and changed: if the badge is not awarded, the self-assessment can be repeated after three

months and reach a higher category, after receiving a beginner badge - after a year to reach a higher badge, for experienced schools the badge is valid for 18 months.

Another important STEM Project is "Improving STEAM Education". Partners from seven countries, coordinated by the NATIONAL AGENCY FOR EDUCATION, and eight universities will develop a guide to improving the implementation of STEM education in schools, a set of STEM good practices consisting of tasks of varying complexity or ability, different job descriptions and examples of good practice. There will also be a competency development program for teachers and STEM center methodologists, recommendations on how to develop STEM competencies in schools, and how to improve activities.

9.8. Best practice curricular/methodological models for the integration of STEM skills in general education subjects at the lower/upper-secondary level that exist in Lithuania, practical teaching/ learning arrangement in distance education

"Why do we sort waste?" (Grade 2) (nature, mathematics, Lithuanian language)

Students learnt how long it takes for different types of waste such as paper, plastic, glass, and metal to decompose. They found out that the number in the middle of the recycling mark on the packaging indicates the material the packaging is made of. They put their theoretical knowledge into practice by spending three days sorting waste, weighing it and drawing diagrams.

"Making a greenhouse" (grade 6) (biology, physics, information technologies)

Students made greenhouses at home from the available material and measured their temperature after a while. The one greenhouse was kept in the shade and the other in a sunny place. Students discussed their findings and analysed the gathered information about the consequences of the "greenhouse effect" in a remote lesson.

„Composition of the spatial shapes made of snow " or Composition of spatial shapes

"The Castle of My Dreams" (made of paper and other materials) "(Grade 6) (maths)

Students recalled and described the spatial shapes, made them from paper, moulded out of snow or constructed them out of other materials.

Project activity "My Little World" (Grade 3).

Students constructed a biome/terrarium in a container, an environment suitable for plants to live in, and learnt about the surrounding nature, its needs and the plants that grow there.

"The properties of water " (Grade 2)

Pupils explored the different properties of water. When snow melts, less water remains.

Salt melts ice.

The pupils found out that taste receptors are located in different parts of the tongue.

9.9. Possibilities and recommendations for the integration of STEM fields into the secondary school curriculum

If we want to integrate STEM fields into the secondary school curriculum we need to:

- To strengthen teachers' competencies in STEM education.
- To expand the material base of education - to equip environments and laboratories suitable for STEM teaching.
- To enable teachers to work with smaller groups of students. Allow each student to feel success.
- Teachers should collaborate more, work in teams, prepare integrated tasks based on experiential education, organize research activities and relate the content of the lesson to everyday experiences.
- To apply methods of cooperation and group work, to experiment, to base the theory on practical activities in the educational process.
- To transfer education from school to non-traditional places such as museums, parks, and business institutions.
- To support teachers by funding additional posts for teacher assistants.

9.10. Needs of organisations/ entities in Lithuania in the field of STEM education with regard to the adequate competencies of teachers in distance teaching/ learning

Panevezio "Zemynos" progymnasium teachers need:

- To acquire the competences to implement integrated education;
- To improve collaborative practices and teamwork.
- To develop student's leadership, critical and creative thinking by teaching them remotely.

9.11. National strategies and current national curriculum in Lithuania with regard to STEM education concerning digital education readiness (using SWOT analysis)

Schools of Science, Technology and Technology Mathematics infrastructure (training tools and equipment) has been in place for a long time critical - STEM sciences were studied at the theoretical level. One of the reasons for this is schools did not have the necessary infrastructure: teaching aids and equipment, laboratories. 2009-2014 implemented an infrastructure development project "Technology, Arts and Nature 404 countries schools received teaching aids, equipment and furniture science, technology and arts to teach things. Acquired tools and equipment satisfied part of the basic practical nature, arts and technological science training needs. However, it is important to note that in most countries schools still do not have opportunities to organize practical STEM training, hence the gap between the current - theoretical and achievable - practical, experiential, empirical cognition-based training is striking. Inadequate, inefficient provision of schools for these sciences means and equipment cause problems such as low levels of natural, popularity of mathematics, technology in school and elective studies, low preparation of students for successful professional careers, lack of supply and demand for non-formal education, insufficient motivation of teachers to work in STEM education. Students do not have the opportunity to apply the knowledge gained during lessons in practice, many do not have the opportunity to deepen their knowledge, to conduct tests and experiments. This is true for both those with higher abilities students and low-achieving teaching. When discussing the condition of the infrastructure and its needs, it is also important to note that the country's municipalities do not have the resources to provide modern laboratory equipment for all their schools - in addition the schools themselves do not have the specialists needed for STEM practical training either training programs adapted for practical training in laboratories.

Quality non-formal education for children is one way of complimenting the competencies acquired in formal education. Together it is a great opportunity to encourage students to take an interest in STEM areas. However non-formal education in the field of STEM is not popular in Lithuania because of the lack of existing supply caused by modern infrastructure, professionals and, accordingly, children lack.

9.12. National strategies in the field of education, current national curriculum, and fields that (in)directly cover STEM education regarding teaching standards, innovative pedagogies and didactic materials used in cross-curricular investigation of digital education

In Lithuania, education can take place outside school (for practical and theoretical courses), e.g. in museums, parks, etc., by adjusting the educational process (active education of pupils, personalised learning, managing groups of various sizes depending on activities, etc.). Pupils can choose subject modules, including STEM modules, according to their interests and abilities. As a national strategy in Lithuania several events are organised to support and promote interest in STEM studies or careers, such as the yearly "Spaceship – Earth"17 science festival, the Researchers' Night event, as well as yearly Olympiads of various STEM disciplines18 and other national mathematical and natural science literacy contests. These kinds of initiatives enable students to participate and practise STEM together with educators, academics, the research community, parents, professionals, etc. They change teachers' practices by familiarising them with modern training methods and learner-centric approaches. However, these guidelines and programmes do not involve the whole of the student population and depend on the investment of local educational communities. In Lithuania, since 2017 there has been a pilot of ten primary schools for developing teaching/learning material and preparing recommendations for the integration of informatics into the primary education curriculum. Devices for science and technology laboratories are provided to many schools. Under the project "Technology, Arts and Natural Sciences Infrastructure", 404 schools received equipment, tools, furniture for science, technology and art classrooms. Many digital learning resources can be found on the website "Ugdymo Sodas".

9.13. Detailed needs of the organisations/ entities/institutions/schools in Lithuania in the field of STEM education with regard to the digital contents into the school curriculum in full compliance with the distance learning and teaching

It would be useful if teachers had the possibility to need gain STEM teaching experiences via virtual teaching practices, where other educators share successful examples of experiential teaching, curricula, tasks of different complexity as well. Teachers are short of STEM tasks adapted to pupils of different abilities, practical works and experiments. Furthermore, it would be very useful to use some learning portals where teachers can discover, use and enhance online labs appropriate for their courses and students can acquire scientific methodology skills while doing experiments using the labs as well.

10. Conclusion

Intellectual output 1 provides an overview of partner activities in the field of STEM education. Although these are countries of different political, economic systems, the idea of the importance of digital STEM labs shows that the system is less important.

The document looks at school systems in Türkiye, Greece, Spain and Lithuania and current curricula, with a focus on incorporating digital STEM materials into formal education.

The idea of valorizing STEM education as an important element of one's own identity, and the great number of examples and practices, demonstrate the willingness of the partners to engage in curriculum creation, which has not yet been developed. The diversity of school curricula does not prove to be an obstacle to the idea of curriculum creation and piloting; moreover, it provides an opportunity to include different activities and examples of good practice.

Intellectual output in several categories enumerates activities in the previous work of partners and various examples of formal and non-formal STEM education. Willingness to present in a comprehensive way the necessary information for the following project activities also indicates a willingness to actively participate in curriculum development.

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