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## TRANSNATIONAL REPORT



### State of the art analyze about Green STEM education practices



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## INTRODUCTION

The extensive advancements in science in recent years challenge the knowledge of today's students. They must possess the ability to comprehend and synthesize new information. The daily tasks confronting contemporary students are progressively becoming more complex and demanding. Traditional teaching methods have proven inadequate in delivering the desired outcomes, prompting educators to seek more effective approaches.

STEM education, centered on integration and inclusion within real-life scenarios, offers a means to motivate and engage students. This educational approach necessitates the execution of specific learning activities to cultivate students' problem-solving skills through creative techniques, facilitating their seamless integration into professional and social spheres. STEM education equips students to stay abreast of technological innovation.

STEM education fosters intellectual growth, entrepreneurship, and the advancement of the entire society. Entrepreneurship entails individuals taking initiative to actualize their aspirations and taking calculated risks. It also enhances awareness and production skills.

Science, technology, engineering, and mathematics (STEM) education play a pivotal role in preparing students for the demands of the twenty-first century workforce, as it encompasses the knowledge and competencies essential for creative problem-solving, critical thinking, and innovative solutions. It is a cornerstone of high-quality education, vital for national economic growth and prosperity. This report assesses the current state of STEM education, its challenges, and recommendations for enhancing its outcomes.

The STEM Reports from Bulgaria, Türkiye, Slovenia and Greece offers a comprehensive evaluation of the existing state of science, technology, engineering, and mathematics (STEM) education. This report includes an analysis of the workforce, policy recommendations, and an appraisal of STEM education's outcomes in schools and universities.

Today, it is widely acknowledged that science, technology, mathematics, and engineering are fundamental components of a nation's development. As a result, many nations are investing in the STEM approach to nurture future generations in these fields. In this context, various



reports and documents have been prepared by the responsible educational institution, laying the groundwork for the implementation and dissemination of the STEM approach. These reports and documents have underscored the importance of STEM education, drawing the attention of education experts, institutions, and the business community.

In relation to STEM education, the educational institution has actively participated as a national support entity in the Scientix Project, a collaborative project for science education in Europe, led by the European Schoolnet since 2014. This project encourages and supports Europe-wide collaboration among STEM (science, technology, engineering, and mathematics) teachers, education researchers, policy makers, and other STEM education professionals. The project aims to promote the use of technology and best practices in science education across Europe through the establishment of teacher communities.

One of the initial reports produced to promote STEM education in Türkiye is the "STEM Education Report" prepared in 2015 and hosted by Istanbul Aydın University. This report has underscored the need for STEM education and outlined a roadmap for its implementation.

The core of the report focuses on a comprehensive examination of the current state of green STEAM education in the country. Although green transition and sustainability are partially integrated into various educational stages, their most robust integration is observed in tertiary education and research institutions. Nevertheless, there is a notable absence of systematic incorporation of green technologies and sustainability into educational frameworks. Encouragingly, numerous initiatives are underway at different educational levels to address this gap on a national scale.

Through green STEAM education, individuals should be equipped with the knowledge and skills required to address environmental challenges and establish a sustainable and resilient world. By promoting the application of arts, technology, and scientific principles in an environmentally conscious manner, we inspire the next generation to become environmentally responsible innovators.

STEAM education has gained significant attention and recognition in recent years, representing an interdisciplinary learning approach that nurtures creativity, critical thinking,



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problem-solving, and collaboration among students. The government, educational institutions, and various non-governmental organizations are actively championing STEAM initiatives to foster innovation and prepare the next generation for a technology-driven and rapidly evolving world.

## **CURRENT STATE AND TRANSNATIONAL ANALYSIS FROM THE NATIONAL STEM REPORTS**



*STEM Approach in Bulgaria's Education System:*

The state of STEM education in Bulgaria has emerged as a top priority for educational development in recent years. However, there is still considerable work needed to establish high-quality STEM education in the country. Several key challenges include:

1. Funding: Insufficient funding for education in Bulgaria has a direct impact on the quality of STEM education.
2. Inadequate Teacher Training: Teachers in Bulgarian schools require additional training to effectively deliver high-quality STEM education. Without this training, they may struggle to guide students in the STEM field.
3. Limited University-School Collaboration: Greater collaboration between universities and schools could significantly enhance the quality of STEM education by providing students with a more comprehensive learning experience.
4. Shortage of Practical Training Opportunities: Practical training opportunities in STEM education are limited in Bulgaria, preventing students from applying their theoretical knowledge effectively in real-world scenarios.

Despite these challenges, an increasing number of schools in Bulgaria are prioritizing STEM education, which will help prepare the next generation of STEM professionals in the country. The initiative began in the 2018/2019 academic year when schools began organizing extracurricular activities based on STEM fields such as science, technology, engineering, and mathematics. The "Building a School STEM Environment" program, initiated by the Ministry of Education in 2020, aims to establish new STEM school centers.

According to this program, each new school center will involve improving classroom infrastructure, introducing innovative educational content, and implementing diverse teaching methods. Additionally, Bulgaria has various projects focused on STEM education:

- The "STEM Centers and Innovations in Education" project, part of the "Building a School STEM Environment" initiative, aims to establish over 2,240 STEM centers in all schools by 2026. The project's goals include building an educational STEM environment, developing students' STEM skills, and enhancing their readiness for the job market.



- The "Innovations in Action" program, Module 5, supports schools and teachers in implementing innovative activities, fostering an innovative learning environment, and promoting innovative teaching methods. It focuses on natural sciences, digital technologies, engineering, and mathematics (STEM).

#### *STEM Approach in Türkiye's Education System:*

In Türkiye, the 2013 Pre-School Education Program serves as the foundation for pre-school education. While it doesn't explicitly emphasize STEM education, it includes achievements and indicators related to cognitive development that align with STEM education principles. Several universities in Türkiye, such as METU, YTU, and Bahçeşehir, conduct training programs for preschool teachers to raise awareness and knowledge about STEM practices.

In secondary school curricula, STEM education is not explicitly mentioned in STEM courses (Physics, Chemistry, Biology, Mathematics, and Computer Science). The applications of STEM are either absent or receive minimal attention in the curriculum.

In university and faculty of education curricula in Türkiye, there has been a growing focus on STEM education. Universities conduct various activities, including teacher training, integrating STEM courses, and organizing scientific events to promote STEM. However, the undergraduate curricula do not include direct STEM education courses, with some exceptions in Science and Primary School Mathematics Teaching departments.

#### *STEM Approach in Slovenia's Education System:*

The education system in Slovenia consists of primary, secondary, and tertiary education, with provisions for adult and special needs education. The primary education cycle includes subjects like Mathematics, Fine Art, Music, and Fundamentals of the Environment, which align with STEM education principles. The curriculum of the Fundamentals of the Environment course also covers green technologies.

In the secondary education cycle, the spectrum of STEM subjects expands to include Mathematics, Fine Art, Music, Natural Science, Natural Science and Technology, and Engineering



and Technology, all of which incorporate references to green technologies. Technical courses delve into four interconnected domains: Technical Resources, Technological Processes, Organizational Dynamics, and Economic Considerations.

In the third educational cycle, subject-specialist teachers lead instruction, offering a comprehensive exploration of STEM courses. Students can choose from a range of elective courses, some of which have direct or indirect connections to green technologies.

Upper secondary education in Slovenia includes both general education and technical and vocational education. The general education curriculum includes compulsory STEM subjects and a variety of STEM electives, allowing for more advanced study in Biology, Physics, Chemistry, Mathematics, and Informatics. Technical and vocational education provides specialized STEM courses, delving into various technical and natural fields. It offers an in-depth understanding of technical and scientific disciplines and introduces specialized courses related to Green STEM.

In summary, while both Bulgaria, Türkiye and Slovenia face challenges in implementing STEM education, they are actively working on initiatives to improve the quality and availability of STEM education. In contrast, Slovenia has made substantial progress in incorporating STEM principles and green technologies into its education system, starting from the early stages of primary education and continuing through upper secondary education.

#### *STEM Approach in Greece's Education System:*

STEM education interests research conducted by Greek researchers. Many studies published concern certain STEM fields, e.g., robotics, and environmental issues. Integrated STEM approaches appear only in few studies. The need of teachers' professional development is highlighted.

Three exploratory empirical studies were contacted in Greece under the "Green STEM" framework. Twenty-six reported that they followed the integrated STEM education approach. They also mentioned that STEM related teaching contributes to a better understanding of the topics taught. Most of the 12 master's students asked, considered that STEM approach offers





them motivation to learn, contributes to better understanding and critical thinking, prepares them for the real life and work. The nine researchers indicated that there is a need for properly designed training programs for both future and in-service teachers.

The report on STEM education in Greece shows that the integrated STEM approach is proposed at all educational levels and is followed at a certain degree. The integrated STEM approach incorporating the engineering design process has to be enhanced. Professional development involving purposeful seminars is needed. Educational scenarios that follow the integrated STEM approach have to be developed.



## STRATEGY AND PLAN FOR IMPLEMENTING A MODEL FOR TRAINING STUDENTS AND TEACHERS TO APPLY THE GREEN STEM STRATEGY

STEM education places a strong emphasis on universal literacy skills, including creative thinking, critical thinking, problem-solving, and collaborative learning. Students are expected to attain these skills, and teachers play a pivotal role in guiding students to achieve higher-order thinking, product development, invention, and innovation. Rather than merely imparting theoretical content knowledge in science, technology, engineering, and mathematics, teachers create a supportive learning environment where students feel comfortable exploring without fear of failure. Thus, teachers lead by example, nurturing students' confidence and creativity.

The primary goals of this program encompass:

1. Enhancing students' motivation for natural sciences and mathematics, making learning more engaging.
2. Facilitating project-based learning, integrating complex knowledge, and shifting educational paradigms toward a more comprehensive and contemporary approach.
3. Increasing student engagement, skills, achievements, digital literacy, creativity, and industry-relevant competencies.
4. Equipping students with problem-solving skills, fostering technological solutions, teamwork, and critical thinking.
5. Stimulating students to innovate and improve modern technological solutions, particularly in the fields of mechanics, programming, and artificial intelligence.
6. Developing skills for creating new technologies and automating existing processes.
7. Attracting more students to university majors and careers in technology-related industries.
8. Contributing to the growth of technology industries and their share of the GDP.



In the digital age, STEM education is of paramount importance and should be swiftly implemented to cultivate essential skills. Introducing the STEM methodology not only sparks students' interest in natural sciences but also guides them toward careers in STEM fields. This educational approach equips students with the skills and competencies necessary for a successful future, emphasizing critical thinking and the application of these skills to create innovative solutions.

Survey to gauge the attitudes of teachers and experts in Bulgaria regarding the introduction of STEM education and its associated premises and recommendations, a survey with eight questions (Appendix 2) has been developed. This survey seeks to achieve several objectives, including:

- Assessing the overall attitude of teachers and experts toward STEM education.
- Evaluating the role of STEM classes in practical science education.
- Understanding the shift in science and teachers' readiness to embrace innovation in STEM teaching with the support of ICT.

The survey results lead to the following conclusions:

- STEM methodology increases students' engagement with natural science topics.
- Innovative STEM teaching positively impacts student engagement and performance.
- The absence of adequate Bulgarian-language content complicates the development of STEM lessons for teachers.
- While a significant portion of participants utilize STEM software in STEM classes, some teachers do not use it or use it infrequently. This indicates a need for more training and resources to promote the use of STEM software in education.

To determine state-of-the art research initiatives in the Web of Science (WoS) and TR-Indexed Papers in Turkey, Turkish partners analysed 226 papers on STEM education. They used specific search criteria to identify articles conducted within Turkish universities, schools, and institutions. They analysed published papers based on various aspects, such as titles, objectives, methodologies, participants, and results. They also compiled all data files into a open access



database for further analysis. Their analysis aimed to identify patterns, trends, and relationships among the papers by summarizing critical key findings and categorizing them for a more systematic understanding. Moreover, another analysis was carried out by Turkish partners for the collection of national theses from official databases (YÖK Thesis). These theses were selected to extract information about their research objectives, methods, findings, and participants, and their data was organized for a descriptive analysis. This analysis revealed the frequency of STEM education topics, research methods, and the involvement of various participants in Turkish thesis landscape. Additionally, STEM centers are integral to STEM education initiatives in Türkiye. These centers, mostly associated with universities, research institutions, or other organizations, and play a vital role in provoking STEM education. Their roles encompass:

1. Developing and implementing STEM education activities aligned with national standards, promoting hands-on learning opportunities.
2. Providing training and professional development for teachers to enhance their STEM teaching skills.
3. Offering valuable STEM resources, including books, journals, software, and hardware, for both students and teachers.
4. Supporting research in STEM education, aiming to create evidence-based teaching and learning strategies.
5. Collaborating with industry partners to expose students to real-world STEM experiences and insights into STEM careers, creating industry-academia alliances.

Green Education and Research at University of Ljubljana Slovenia, particularly the University of Ljubljana, is a proud member of the EU STEM Coalition, a network dedicated to advancing STEM education throughout Europe. This coalition focuses on crafting and implementing STEM education policies and strategies, aiming to drive economic growth, create opportunities, and improve overall well-being. By collaborating with policymakers, educational institutions, and industry stakeholders, the coalition seeks to innovate educational delivery and share evidence-based solutions addressing skill mismatches in STEM fields.



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The University of Ljubljana is actively involved in initiatives to nurture STEM talent. These initiatives include collaborative efforts through Quadhelix partnerships, engagement in STEM activities within MakerLabs and FabLabs, and the organization of summer and winter schools, along with CAMPs for students in elementary and secondary education. The university also plays a significant role in formulating a comprehensive national STEM strategy and offers specialized training sessions for students, parents, and educators.

Research ventures conducted by the University of Ljubljana address critical issues such as Sustainable Innovation, Climate Change Mitigation, Environmental Awareness, Cross-disciplinary Collaboration, Green Career Opportunities, Resilient Communities, and Global Impact. Additionally, the university's faculties offer study programs focused on Delivering the European Green Deal, aiming to transform the economy and society. Projects are also undertaken to bridge the gap between theoretical concepts and practical implementation, and these ventures contribute to sustainable progress, both locally and globally.

By actively participating in the EU STEM Coalition and pursuing numerous initiatives and research projects, the University of Ljubljana plays a pivotal role in advancing STEM education, fostering innovation, and addressing critical environmental and societal challenges.



## CONCLUSIONS AND RECOMMENDATIONS

### Recommendations

To enhance the status of STEM education in the partner countries, the following recommendations are proposed:

- **Enhancement of Teacher Training:** The government should prioritize STEM teacher training and initiate programs to attract and retain qualified STEM educators.
- **Investment in STEM Education:** Increased funding should be allocated to STEM initiatives, including the provision of equipment, laboratories, and technology.
- **Collaboration with STEM Professionals:** Strengthen collaboration between STEM education stakeholders, educators, and STEM professionals to offer students insights into the real-world applications of STEM across various industries.
- **Expanded Access to STEM Opportunities:** The government should implement initiatives ensuring equal access to STEM education opportunities for all demographic groups.

### Conclusion

STEM education is a fundamental component of an innovative educational system and plays a crucial role in a nation's economic growth and prosperity. By investing in teacher training, increasing financial support, fostering collaborations, and improving access to STEM opportunities, Bulgaria can enhance STEM education outcomes and prepare a skilled workforce for the challenges of the twenty-first century.

In summary, an analysis of academic research, reports, and studies conducted within STEM centers underscores a wide array of applications, projects, and workshops aimed at advancing STEM education in Turkey. Additionally, supportive initiatives for newly established centers are evident. Valuable educational resources, including books and brochures, are being developed to assist both teachers and students in their pursuit of academic excellence. These endeavors underscore the significance of STEM education and the commitment of Turkish institutions to cultivating a thriving culture of scientific exploration and technological innovation.



Nonetheless, the path ahead is still evolving, and this notable progress lays a strong foundation for an ongoing journey of improvement. As educational systems continuously adapt and the demands of the modern world undergo transformation, the relentless pursuit of excellence remains a guiding principle. This unwavering dedication to nurturing critical thinking, problem-solving, and creativity within students ensures that Slovenia is poised to maintain its distinguished position in the realm of Green STEAM education. This, in turn, significantly contributes to a future characterized by remarkable technological advancements and enriched insights in vital areas such as Sustainable Innovation, Climate Change Mitigation, Environmental Awareness, Resilient Communities, and Global Impact.

STEAM education in Slovenia is unquestionably charting a positive trajectory, reinforced by a resolute commitment to equipping students with essential skills, comprehensive knowledge, and an adaptable mindset essential for success in a technology-driven society. At the core of this educational transformation lies a strong emphasis on experiential learning, weaving together various disciplines to facilitate holistic comprehension. By fostering an environment where hands-on exploration flourishes, Slovenia nurtures fertile ground for students to grasp complex concepts through tangible engagement.

Furthermore, Slovenia's strategic partnerships with industries amplify the practical applicability of education. By bridging academia and industry, students gain access to real-world insights, cutting-edge developments, and the opportunity to work on projects mirroring actual professional scenarios. This mutually beneficial relationship enhances the quality of education and prepares students to make meaningful contributions as they transition into the workforce.

In essence, Slovenia's dynamic approach to STEAM education is a strategic investment that goes beyond producing proficient graduates; it shapes proactive problem solvers and forward-thinking innovators. This transformative education doesn't confine itself to national borders; it resonates globally. The solutions incubated within Slovenian classrooms have the potential to address not only local challenges but also a broader spectrum of global issues, from environmental sustainability and resource management to healthcare advancements and technological breakthroughs. Slovenia is forging a path towards systematically introducing



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sustainability and green transition in education that extends far beyond the classroom, shaping a future where knowledge and ingenuity act as driving forces for progress.

Notably, the educational landscape in Bulgaria, Türkiye, Slovenia and Greece thrives on interdisciplinary approaches, transcending traditional course boundaries. This approach not only mirrors the dynamics of the real world but also cultivates in students the ability to connect ideas across seemingly unrelated domains. As a result, learners are prepared to tackle multifaceted challenges by approaching them from diverse perspectives, fostering an innovative mindset with immense potential.





## THE STATE OF THE ART ANALYZE ABOUT STEM EDUCATION PRACTICES IN BULGARIA

### STEM education

Modern world trends in education are primarily related to the forms, methods and means of teaching and learning, aiming at a diverse, dynamic, interesting and effective educational process. Therefore, the reforms that have been carried out in the last few years in school education in Bulgaria are in line with these global trends in education and require the modernization of traditional forms, methods and means of education by using new and diverse ones (Grancharova, 2019 ).

The exceptional and intensive development of science in recent years puts the knowledge of today's students to the test. They must know and be able to synthesize new information. The tasks that today's students face on a daily basis are becoming increasingly difficult and responsible. The previous methods used in training could not provide the necessary results and expectations for their solution. That is why teachers have to look for new, much more effective methods.

STEM learning based on integration and inclusion in the learning process of a real-life situation is a way to help students learn motivated. This training requires the implementation of a specific lesson activity in order to form students' skills to solve real-life problems using creative techniques and thus be easily integrated into working and social life. STEM education is what prepares students to keep pace with technological innovation.

*STEM education* is a type of integrated education with a focus on the formation and development of science literacy. This is because:

- the organization of this type of training is a reflection of the modern state of natural sciences and related technologies;
- the growth of worldwide interconnectedness (globalization), global environmental problems of pollution and environmental protection, and our obligations to find the right solutions require a direct connection of education with global issues;



➤ the formation and development of interdisciplinary and transdisciplinary skills and competences helps students to discover and clarify scientific and life problems and to apply the acquired knowledge and skills to solve them.

Integrated STEM learning is based on an integrated approach to traditional subjects that allows students to learn how to solve real-world problems. This training helps them to comprehensively understand the concepts, processes and laws in an integral society. There are multiple definitions of STEM integration. According to Sanders (2009), STEM integration occurs in teaching and learning between two or more STEM subject areas. It sees integration as consciously designed outcomes where at least one of the STEM subjects of study is well mastered through the help of another subject of study. For example, teaching mathematics and its relevance to science, how technology affects the development of engineering, etc. ( Sanders , 2008). Moor and Smith (2014) describe integrated STEM education as an attempt to create a single course of study (a subject of study - STEM ) that unites all STEM disciplines, or delivering lessons on real-world topics that combine knowledge of more than two STEM academic subjects ( Moor & Smith, 2014). They further add that an integrated STEM curriculum may include STEM content and learning objectives focused on one subject, but the context may be from other STEM subjects. Integration in STEM education is also understood by some authors as focusing on the study of natural sciences and mathematics as separate subjects, in which content from technology and engineering is included (Breiner et al ., 2012). STEM integration is also achieved through common approaches to teaching and learning across the curriculum. Many of these teaching approaches promote the integration of STEM learning and STEM skill building activities . Carrying out practical and experimental activities in the teaching of STEM subjects builds a wide range of "soft" skills that are used by students in all subjects. In this way, the integration of STEM subjects creates a prerequisite for "rethinking education as a whole in an innovative way" ( Peppler and Bender , 2013). Integrative STEM education typically involves multidisciplinary teaching and is aimed at developing students' problem-framing and problem-solving skills, as well as their ability to contextualize scientific knowledge concepts to real-life situations.



STEM education supports intellectual development, entrepreneurship and the development of an entire nation. Entrepreneurship is about people taking the initiative to make their dreams come true and taking action. Entrepreneurship is a risk-taking process and also provides awareness and production skills.

Another goal of STEM education is to bridge the gap between different disciplines, namely to create full integration (Wang, 2012) and raise a generation with research skills, productive and inventive from kindergarten to university. STEM education aims to identify students' curiosity and research skills in primary and secondary schools and guides and encourages students in science, technology, engineering and mathematics departments of universities in general.

Science, technology, engineering, and mathematics ( STEM ) education plays a vital role in preparing students for the twenty-first century workforce because it encompasses the knowledge and skills needed for creative problem solving, critical thinking, and innovative solutions. It is an essential component of high-quality education and essential to national economic growth and prosperity. This report examines the current state of STEM education in Bulgaria, its challenges and recommendations for improving the results of STEM education.

STEM Report provides a comprehensive assessment of the current state of science, technology, engineering and mathematics ( STEM ) education in a country. The report includes a workforce analysis, policy recommendations and an assessment of the outcomes of STEM education in schools and universities.

In recent years, significant efforts have been made in Bulgaria to improve STEM education. The government is focusing on developing a national strategy to support STEM methodology and innovation, with plans to increase research funding and investment in STEM infrastructure. In addition, there are collaborations between schools, universities and industries to support STEM learning and create internship and work opportunities for young scientists.

In recent years, Bulgaria has also actively participated in international STEM competitions, in which it has taken first place in many international Olympiads in physics and mathematics.

However, there are still some challenges she faces to improve her results in STEM . One of the challenges is the unsatisfactory level of funding for science and technology education,



resulting in inadequate training and insufficiently innovative materials for teachers and few scholarships for students to pursue careers in science and technology. Another challenge is the lack of equipment and technology in some schools, which hinders the ability of students to carry out laboratory experiments or participate in project-based learning and cross-curricular integration.

Overall, the purpose of the National STEM Report for Bulgaria is to provide a more detailed picture of the current state of STEM education in the country and to identify key areas for improvement to support the growth and development of the STEM workforce.

## The state of STEM education in Bulgaria

STEM education in Bulgaria has been gradually introduced in recent years as an absolute priority for the development of education. However, there is still much work to be done to achieve high quality STEM education in the country.

1. Funding: Funding for education in Bulgaria is generally insufficient, which has an impact on STEM education;
2. Insufficient teacher training: School teachers require additional training to achieve high quality STEM education. Without such training, they will not be able to guide their students properly in the STEM field;
3. Insufficient cooperation between universities and schools: The possibility of cooperation between universities and schools could help students get a better education in the STEM field;
4. Lack of opportunities for practical training: Opportunities for practical training in STEM education in Bulgaria are still limited. For this reason, students often cannot apply their theoretical knowledge in practice.

Despite these challenges, more and more schools in Bulgaria are introducing STEM education as a priority for their students. This will help prepare the next generation of STEM professionals in Bulgaria.



## STEM and the Ministry of Education and Science

According to Bulgaria's national strategy, STEM education focuses on universal literacy skills. These skills are creative thinking, critical thinking, problem solving and collaborative learning. Students must achieve these skills. In this context, the role of teachers is to help students reach a higher level of thinking, product development, invention and innovation by leading but not teaching theoretical content knowledge in science, technology, engineering and mathematics. It is important to create a learning environment where students are not afraid of failure and are confident. Therefore, the role of teachers is to help students reach the level of higher-order thinking, product development, invention, and innovation by leading, but not teaching them, science, technology, engineering, and mathematics.

The idea of introducing the STEM methodology in Bulgarian education is not recent. In April 2018, Bulgaria became a member of the European STEM Coalition, which includes national STEM platforms and organizations responsible for the implementation of national STEM strategies. One of the most important tasks of the European STEM Coalition is to facilitate the interconnection of sharing good practices between different countries and to support the development of new educational platforms. In Bulgaria, one is about to be created with an emphasis on digital skills at all levels in school and higher education, discovering the technical talent of adolescents at an early stage and attracting expert teachers ([www.mon.bg](http://www.mon.bg)). The first steps were taken in the academic year 2018/2019, when schools began to organize and involve students in extracurricular activities that are based on the main STEM fields - science, technology, engineering and mathematics. "Building a school STEM environment" is a national program of the Ministry of Education from 2020, which aims to create new STEM school centers. They integrate various methodologies, with the focus being on the study and application of various key competencies in the field of natural and mathematical sciences in all schools in the country. According to the above-mentioned program of the Ministry of Education and Culture, each newly built school center will include the following parts - improvement of the internal architecture and furnishing of existing classrooms, information technologies, new and more innovative educational content, different methods of teaching and managing the educational process in the



classroom room. The program targets schools with innovative practices and those with the potential to develop innovations in the fields of natural sciences, digital technologies, engineering thinking and mathematics (STEM). The main goal in the implementation of the program is to motivate students to study natural sciences, mathematics and technologies, increase educational results, acquire a system of competences, permanent, comprehensive knowledge, key skills and attitudes oriented towards practice, development and career orientation of students, directing them to technological professions. The program is aimed at creating an integrated learning environment of a new generation in Bulgarian schools, which will encourage and support educational innovations in learning and teaching in the field of STEM, creativity and research. The investments will support the introduction of new teaching methods, increase the qualification of pedagogical specialists and create new educational content in the direction of integrating the subject areas of STEM. The purpose of the program is to invest in comprehensive integrated solutions for a new school creative environment with a focus on science, engineering, mathematics and technology (STEM), including different elements according to the specific need of the school and the school community: remodeling of existing spaces, technology , new teaching methods, new or integrated learning content, new organization of the learning process, supportive environment for students with special educational needs if necessary. The final product of the program will be technology centers in schools, which are an integrated collection of classrooms and other learning spaces in schools, creating a culture of innovation among school communities. Thus, the National Program will create "models" in part of the Bulgarian schools to prove the process of successful investment in a comprehensive idea, including learning environment, technologies, management, integrated content, qualification and teaching methods (<https://web.mon.bg/bg/101212>).



**The main objectives of the program are:**

- ✓ To increase students' motivation for learning natural sciences and mathematics;
- ✓ To create opportunities for project-based learning, integrative complex knowledge, understandable learning in natural sciences with modern scientific topics and change of educational paradigms;
- ✓ To increase students' engagement, skills and achievements, their digital literacy, creativity,
- ✓ To create skills to meet industry requirements,
- ✓ To form skills for solving real life problems, for creating technological solutions, teamwork, critical thinking, etc.);
- ✓ To stimulate students to create and improve modern technological solutions in the field of mechanics, programming and artificial intelligence;
- ✓ Skills for creating new technologies and their automation;
- ✓ To increase the number of students interested in university majors and jobs in the technology industries;
- ✓ To contribute to the growth of technology industries and their share of GDP.

The final products of the national program are the creation of innovative learning centers with a focus on STEM, which include a change in the educational environment, learning content, teaching, organization and management of school processes (<https://web.mon.bg/bg/100835>). .

Since 2020, progress has been noticed in Bulgaria in the implementation of more STEM forums and national conferences with the training of natural science and mathematics teachers. They share good practices in the field of STEM education, gather information about new resources and enrich the horizons of innovative teachers.

Unfortunately, even now in 2023, there are still no universities in Bulgaria that teach or start projects in the field of STEM education. Courses to increase STEM educational skills and teacher trainings in various organizations are absolutely insufficient. For the transition to STEM





education in Bulgaria, there is a need to create a new methodology offered in universities and more specifically in the faculties of natural sciences – Chemistry, Physics, Mathematics.

At the national level, we can summarize that the ideas and guidelines proposed by the European Union in terms of a plan for the recovery and sustainability of the Republic of Bulgaria are fully implemented. As one of the main goals are - informing the whole of Europe about projects related to STEM education in Europe, facilitating the distribution and sharing of materials and tools produced by STEM education projects, creating a web-based platform where European national congresses, conferences, seminars or STEM education projects can be announced across Europe, presenting educational materials suitable for inquiry-based learning and adaptable to science and mathematics courses, contributing to the training of STEM teachers through online and face-to-face training.

In the present and communication age, STEM education is extremely important and it is imperative to implement it in the shortest possible time to be able to achieve the necessary skills. Introducing the STEM methodology will increase students' interest in natural sciences and may help them choose a profession in the STEM field. STEM education will help prepare students for life in collaboration with the skills and competencies they need. In the future, their success will increase by using critical thinking, applying skills to develop innovative models.

In Bulgaria, there are several projects aimed at STEM education:

Project " STEM Centers and Innovations in Education" under the PVU Component 2 "Building a school STEM environment". This project envisages the creation of over 2,240 STEM centers in all schools by 2026. The main goals of this project are: building an educational STEM environment, developing students' STEM skills, increasing skills for professional realization on the labor market . The planned areas of the program are five - Natural Sciences, Green Technologies and Sustainable Development, Robotics and Cyberphysical Systems, Design and 3D Prototyping , Mathematics and Informatics.

➤ **Natural Science** - Chemistry, biology, physics and astronomy are part of the natural sciences. In the STEM laboratories, both traditional devices such as microscopes, telescopes, multimeters, but also a **3D printer** for building models, a **smart display** for





visualization and simulation through digital applications can be used. Exemplary experiments could be: dissociation of acids and bases, "silver mirror" and "golden rain"; study of pH of solutions; activity of metals, examination of sunlight by means of a prism; connecting electrical circuits; study of environmental factors through sensors, viewing 3D models of various organs of the human body, observation of tissues and microorganisms under a microscope, preparation of a herbarium with typical plants for the region, observation of objects in space through a telescope, study of constellations and galaxies in a VR environment.  
<https://web.mon.bg/bg/101212>

➤ **Green technologies** - Renewable energy sources (RES) supply energy in a natural way and are not exhausted, but constantly replenished. Renewable energy sources use solar, wind and geothermal energy, hydropower, biomass, etc. for the production of electrical energy. In hydrogen technologies, hydrogen is a universal energy carrier that can be used for almost anything that requires the use of energy. A fuel cell is an energy conversion device that can efficiently capture and use the energy from hydrogen through electrolysis. The use of RES reduces dependence on inorganic fuels, adds diversity in energy sources and reduces greenhouse gas emissions in the atmosphere. Hydrogen fuel cells are environmentally friendly and twice as efficient as traditional combustion technologies. Additional environmental protection measures: separate collection and recycling of waste, water and air purification, preservation of biological diversity; Types of RES: wind generators, hydro facilities, photovoltaics, biofuels.

➤ **Robotics** – Robots are used in almost every sphere of our daily life – personal assistant, medical robot, industrial robot, intelligence and space robot, gaming and racing robot. They can replace a person in an environment that threatens their health, perform repetitive actions or perform a very specific operation. **Cyber-physical systems** represent systems connecting information and software components with mechanical and electronic parts, allowing communication between them through a single infrastructure - for example, the Internet. Sample experiments in a STEM lab: programming a learning stationary robot, programming a learning mobile robot, connecting and programming a sensor system, connecting and programming an IoT system.



➤ **3D design and prototyping** - 3D printers build models using **additive technology** .

3D scanners create non - contact and non-destructive three-dimensional copies of objects. There are different technologies such as optical, tomography and structured light. In these technologies, the material is wound on a roll that is fed to the 3D printer head . 3D scanning is the process of analyzing a real-world object, person , or environment to collect data. The data contains the shape and color of the object. This data finds various applications such as dimensioning, modeling, reengineering, implementation and reconstruction: education, construction, marketing, art, medicine, automotive, architecture, science, engineering.

➤ **Mathematics and Informatics** – Mathematics includes numerous tools to address the integrative issues of STEM learning. Mathematical modeling is an essential element of STEM and is used to find patterns in data. These models can be used to model real and imaginary worlds. Informatics examines how information is transmitted, received, processed, stored, destroyed and presented in the computer world. Data abstraction has reached a high level and through Object-Oriented Programming (OOP) it enables real and imaginary worlds to be represented in the computer. Math is related to art, which is part of STEAM learning. Only by knowing proportion, perspective and symmetry can a work of art be created. The genius Leonardo da Vinci used a mathematical systematization of nature and introduced the term "Golden Section". The activity of the laboratory of mathematics and informatics covers: use of microprocessor systems, modeling, calculations, processing and presentation of data, programming languages C, C++, Python, C#, JavaScript and others, 2D and 3D modeling and data processing, artificial intelligence . <https://web.mon.bg/bg/101212>

The other National Program developed in Bulgaria is called "Innovations in Action" - Module 5, which is aimed at supporting schools and teachers implementing innovative activities through the creation of an innovative learning environment in the classroom, innovative teaching methods, as well as schools with innovative practices and those with the potential to develop innovations in the field of natural sciences, digital technologies, engineering thinking and mathematics ( STEM ). <https://stem.mon.bg/project-methodology-stem-resources-description/>

**Module 5** includes three main steps:



*Activity 1 of the National STEM Center* includes the development of recommendations and methodology for teachers to teach in a STEM environment in the fields of natural sciences and engineering, mathematics and technology, with the aim of increasing the educational results of students, acquiring a system of competences, development and career guidance of students, directing them to technological professions, the professions of the future, engineering sciences and natural and mathematical knowledge.

*Activity 2 of the National STEM Center* is aimed at developing criteria, indicators and methodology for implementation, analysis and evaluation of school teaching resources and toolkit for STEM . The application of criteria and measurable indicators for applicability of the created educational resources will contribute, on the one hand, to their more effective application, and on the other hand, to a more motivating environment of preparation for new educational resources in schools.

*Activity 3 of the National STEM Center* is about developing resources - models for STEM education and their promotion. The creation of educational resources-models aims to demonstrate the application of a common methodology for teaching integrated knowledge, and on the other hand - to create examples and incentives for the application of similar school resources. <https://stem.mon.bg/project-methodology-stem-resources-description/>

## Implementation of STEM projects in Bulgaria

In Bulgaria, various STEM projects have been implemented, aimed at fostering and enhancing synergy in education in the fields of science, technology, engineering, and mathematics.

In 2020, the Ministry of Education and Science of the Republic of Bulgaria launched its national program "Building a school STEM environment" through which to stimulate the creation of new school centers - an integrated set of specially created and equipped learning spaces with a focus on learning and applying competencies in the field of natural sciences in the state and municipal schools in the country. Each school center will include a change in the following elements: physical environment (improvement of the interior architecture and furnishing of



existing spaces), technologies, learning content, teaching methods and management of the educational process. The program is aimed at schools with innovative practices and those with the potential to develop innovations in science, digital technology, engineering thinking and mathematics (STEM).

The program includes two main activities: Activity I: Large projects (up to BGN 300,000) and Activity II: Small projects (up to BGN 50,000). The first activity envisages the projects to be complete, unified centers with a specific focus (such as: Center for Young Researchers; Center for Technologies in Creative Industries; Center for Digital Learning Creators; Center for Science, Research and Innovation) which include several classrooms, as well as the adjacent common spaces. The total value of the project can include a combination of construction and repair activities for the transformation of existing spaces, furniture, equipment, teacher training, creation of integrated learning content and more. The second activity includes projects that will transform and equip smaller physical spaces - one or two classrooms or corners in an existing space. Although smaller in terms of funding, these projects have the same objectives as the larger ones: creating conditions for the development of skills related to creativity in digital technologies; experimental work; developing engineering thinking and problem solving skills; work on projects and assignments with practical orientation in science and technology. The total value of the project can include a combination of construction and repair activities, furniture, equipment, teacher training and more in the following type projects: Corners type "workshops"; Research laboratories; Classroom for creative digital creators.

The national program "Building a school STEM environment" aims to increase students' interest and achievements in the fields of science and technology by supporting the creation of school centers with a focus on STEM. These centers will provide all necessary conditions for conducting modern and high-quality STEM education in schools.

Young people will acquire the necessary knowledge and skills to succeed in future professions.

Students will be educated in an environment and through methods close to the business world and real-life situations. School education will encourage learning through creativity and



the development of innovative solutions to real-world problems. More young people will choose to pursue education and careers in science and technology-related fields.

Young people can have a successful future and a decent life in Bulgaria.

*Each school STEM center encompasses changes in four elements:*

- Educational environment and technologies.
- Educational content.
- Teaching methods.
- Organization and management of school processes.

*The results of scientific research in the field of STEM education are extensive and diverse.*

*Here are some of the key achievements and outcomes:*

- Utilization of innovative teaching methods and approaches: Scientific research has facilitated the implementation of various innovative teaching methods and approaches in STEM education. This includes active and collaborative learning, problem-based learning, game-based learning, and virtual learning, which actively engage students and prepare them for the challenges of the modern world.
- Continuing professional development of teachers: Scientific research supports the professional development of teachers in the field of STEM. This involves providing current knowledge and tools, training on new technologies and methods, and enhancing teachers' communication and mentoring skills.
- Increasing interest and attracting more students: Scientific research helps identify effective ways to increase interest and attract more students to STEM education. This may include the use of stimulating educational materials, extracurricular activities, teacher or mentor programs, and promoting diversity and inclusivity in the STEM field.
- Development of key skills: STEM education, supported by scientific research, focuses on the development of key skills such as critical thinking, problem-solving, creative thinking, and communication skills. These skills are essential for successfully addressing challenges and thriving in the modern world.



## Literature survey on STEM education in Bulgaria, conducted by the international Web of Knowledge database

Regardless of the faster flow of information and innovative technologies that affect each area of our live, the paradox between the technology advancement and the decreased interest of students in science subjects exists.

The data obtained from the international study of the science literacy of Bulgarian pupils in mathematics and natural sciences (from 4th grade and 8th grade) - TIMSS ([https://www.copuo.bg/sites/default/files/uploads/docs/2020-12/TIMSS2019\\_resultati.pdf](https://www.copuo.bg/sites/default/files/uploads/docs/2020-12/TIMSS2019_resultati.pdf)) and PISA ([https://wp.flgr.bg/wp-content/uploads/2019/12/PISA-2018\\_First-Analysis\\_IRE.pdf](https://wp.flgr.bg/wp-content/uploads/2019/12/PISA-2018_First-Analysis_IRE.pdf)) reveal that the results are below of the average values. The most significant is the decline in the field of natural sciences. According to PISA data, the average score of Bulgarian pupils dropped by 22 points in 2018 compared to 2015.

Recently, a national study about the science literacy was conducted amongst 105 teachers through an online questionnaire (with 15 questions) (Todorova, S., 2022). Survey results indicate that teachers apply different methods to build science literacy in students. Part of them knew for the results of PISA and TIMSS made in our country in 2015 and in 2019, but the others -were not familiar. They shared the need of additional methodical help and literature for acquiring further knowledge and skills to improve science literacy among students.

The combination of interdisciplinary, practically oriented approaches to study both disciplines and the application of modern methods (Sabirova, F., et al., 2020) could lead to the formation of a scientific and technical elite.

The literature study that was conducted for searching the phrase „STEM education in Bulgaria” through Web of Science database was limited to find out of 17 publications (Fig. 1).

The results comprise the period between 2011 till May, 2023 and are listed in Appendix 1.



**Fig. 1** Results of Web of Science Core Collection

In 2011, the research focus of Bairaktarova, D. et al. (Bairaktarova, D. et al., 2011) was aimed at development of leadership skills in the field of STEM education in Bulgaria.

At the core of STEM-leadership education is the need in:

- ☞ understanding the technological problems and questions that the society has faced;
- ☞ development of analytical abilities for solving of various problems;
- ☞ efficiency by working in teams and in groups with different origin, cultures and by academic disciplines.

Graham shares that "the mission statements of many undergraduate engineering degrees include aspirations to produce engineering leaders for the 21st Century" (Graham, R., 2009).

As an official discipline – STEM education on leadership is not included in Bulgarian higher institutions. All major engineering, technology and science universities offer management training in a Leadership/Management theory in partnerships with the university's business schools.





In view of leadership education, Bulgaria, as well as other European countries, are in a similar situation. These similarities affect the approach to STEM leadership training focusing on management between Bulgarian universities and one of the American developed programmes.

In order to integrate leadership education in Bulgarian higher institutions and STEM – different approaches such as: interdisciplinary engineering courses and academic technology disciplines; elective courses or leadership training; developing a model for peer learning; different projects with participation of international and global engineering teams. However, considerations must be taken into account - cultural components of leadership education that may influence the selection of the best practices with certain applicability at the local level.

Recently, the changes in educational methods have gained significant popularity, including the expanded use of innovative teaching methods:

➤ **Project-based learning** (PBL) (Wolpert-Gawron, H., 2015). This method provides an opportunity to encourage pupils/ students to learn skills and to apply their knowledge through project participation. They learn how to work in a team, and the important thing is not the achievement of the goal itself, but the path to it. The teacher's role is to facilitate and encourage students to take full control of their projects from the start to the end.

➤ **Problem-based learning** (Nilson, L. B., 2010)  
There are similarities between this method and PBL, with the main difference here being that students have to analyze and evaluate the problem assigned to them. This requires a higher level of mental activity, as there is usually no single answer for the problem. This approach leads to creativity, teamwork and leadership, the idea being to stimulate students to create their own business plans to solve societal needs.

➤ **Inquiry-based learning** (Keselman, A., 2003) (Pedaste, M., et al. 2015) (de Jong, T. 2006) also involves active learning, where the role of students in the learning process is to be encouraged to ask more questions, and the teacher to arouse their curiosity and encourage them to think deeply. By this type of learning, the skills that are developed include critical thinking, questioning and problem solving.





A number of studies indicate that these innovative methods appear to be efficient and lead to improved learning outcomes. According to Connor, A.M., et al. (2015) the main characteristic of all these approaches is that they are focused on students, but the authors define them as initiated by information and communication technologies (ICT). To be able to implement innovative learning activities in a technological environment, teachers need a proper qualifications both in ICT and pedagogy. The research reveals that the majority of STEM teachers consider themselves as qualified enough to take advantage of the modern digitized classroom. Terzieva, V., et al., (2020) show that in a considerable part of Bulgarian schools, technology resources and tools such as computers, multimedia, projectors, and the internet have already been usual for classroom infrastructure but not always are adequate in quantity or technical characteristics.

Other statistics disclose that less than 1/3 of schools have enough technology equipment purchased for the last five years. Therefore, during the last four years, the re-equipment of the computer rooms with modern solutions has started. Thus, students can perceive science subject in a more attractive way. Data indicate that the use of innovative tools is increasingly expanding and has reached a higher level of integration. More and more teachers are already going beyond standard ICT applications and try to use more and more specific ones. Mainly students are those who will take a benefit from technological resources, whereas teachers should enable access through the modern teaching approaches (Terzieva, V., et al., 2020).

## Survey

To establish the attitude of teachers and experts towards the introduction of STEM education, both the premise and the recommendations, it is proposed to fill in a survey with questions (appendix 2). The survey includes 8 questions that are related to the use of STEM resources.

### The goals are:

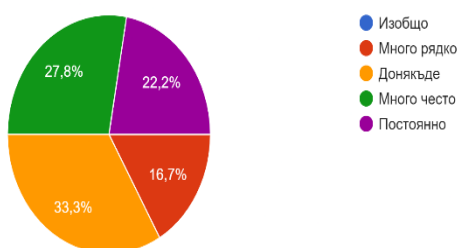
- to determine the attitude of teachers and experts towards *STEM education* ;
- to assess the role of *STEM classes* in doing science;



➤ to capture a shift in science and teachers' readiness to be innovators in STEM teaching with the help of ICT.

To the first question - *How often do you use audio/video materials when teaching STEM classes?*, the responses indicate that audio and video materials are used regularly in teaching STEM education. Almost half of the survey participants apply it to a significant degree. Only 16.7% of participants use them very rarely or not at all. This highlights the importance of visual representation of information in STEM learning.

Колко често използвате аудио/видео материали, когато преподавате в STEM часовете?  
18 отговора



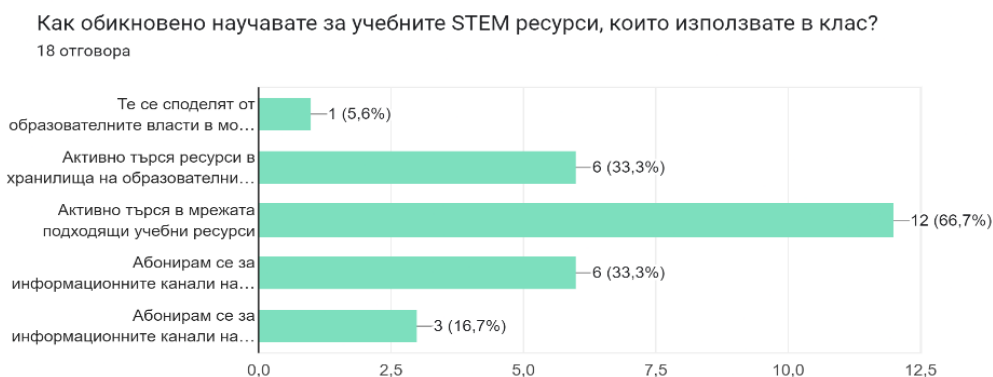
**Fig. 2** *How often do you use audio/video materials when teaching STEM classes?*

From the second question - *How do you usually learn about the STEM educational resources that you use in class?*, it becomes clear that the majority of respondents actively search for information on the Internet. It is noticeable that the help from the educational institutions is absolutely insufficient. From the above results, the following summary can be made: Only 5.6% of the participants found out about STEM learning resources through the educational authorities in their country. This may indicate that not every country provides sufficient available and accessible resources through official channels. 33.3% of participants actively search for STEM learning resources in educational repositories such as Scientix. This indicates that these teachers are aware of existing resources and know how to find them. 66.7% of participants actively search for relevant learning resources on the web. This shows that teachers are willing to use a variety of online resources to find materials that are relevant to their curriculum. 33.3% of participants



subscribe to the information channels of national and international STEM educational projects that are publicly funded. This may indicate that these teachers are actively involved in the STEM education process and follow the innovations and developments in this field. 16.7% of participants subscribe to the information channels of private companies that publish STEM education resources. This may indicate that these teachers are willing to use resources that are produced by private companies, such as software companies or publishers.

Summarizing these results, it can be said that teachers use various sources to find learning STEM resources, such as online resource repositories, national and international projects, and information channels of private companies, but unfortunately educational institutions provide almost no part of them.



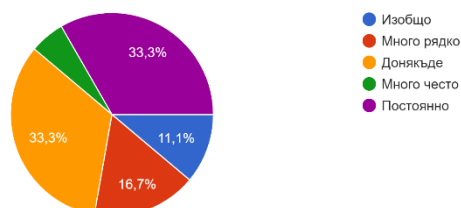
**Fig. 3** How do you usually learn about the STEM learning resources you use in class?

To the third question of the survey, 38.9% answered that they regularly use specific STEM software when teaching STEM classes. This may indicate that these teachers are familiar with different types of software and know how to apply them effectively in the educational process. 11.1% of participants do not use STEM software at all when teaching STEM classes, 16.7% of participants use very rarely, 33.3% of participants only use it sometimes. This may be the result



of a lack of knowledge about these tools, insufficient availability of resources, or the choice of other training methods.

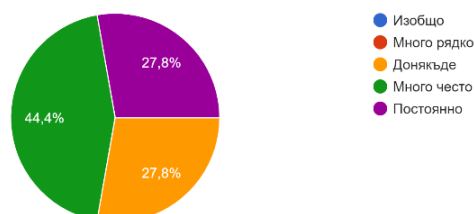
Колко често използвате специфичен за STEM софтуер, когато преподавате в STEM часовете?  
18 отговора



**Fig. 4** How often do you use specific software when teaching STEM classes?

The following graph shows the responses that indicate that insufficient technical support for teachers can have a significant impact on the use of STEM education. Almost three quarters of the survey participants (72.2% - constantly or very often, 27.8% - somewhat) face the problem of lack of technical support. This highlights the need for appropriate technical resources and support for teachers to provide effective STEM learning.

Вашето използване на STEM обучение повлияно ли е от недостатъчна техническа поддръжка за учителите?  
18 отговора



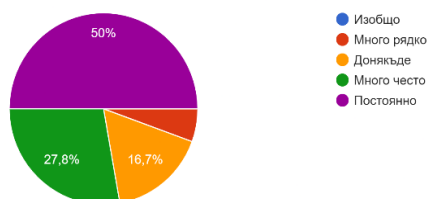
**Fig. 5** Is your use of STEM learning affected by insufficient technical support for teachers?

The answers to this question show that the lack of content in Bulgarian can have a significant impact on the use of STEM education. Half of the survey participants (50% - consistent) stated that this is a factor that influencing their STEM learning practices. More than a third of the



participants (27.8% - very often) also expressed that the lack of content in Bulgarian affects their work. This highlights the need to have appropriate content in Bulgarian for STEM education in order to promote effective learning in these fields.

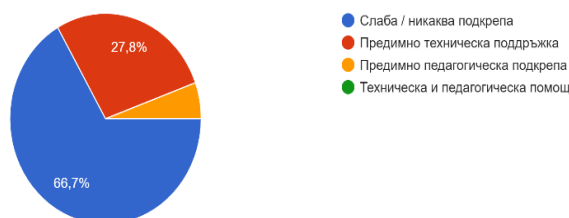
Вашето използване на STEM обучение повлияно ли е от липса на съдържание на български език?  
18 отговора



**Fig. 6** *Is your use of STEM education affected by a lack of content in Bulgarian?*

A summary of the results of this question shows that the majority of teachers do not receive support from experts outside the school to improve their STEM teaching. 66.7% of teachers indicated that they received little or no support, while only 27.8% received mostly technical assistance. Pedagogical support was indicated by only 5.6% of teachers. Also, there is a very small percentage of teachers (5.5%) who very rarely receive technical or pedagogical assistance from experts outside the school. Overall, the results show a lack of expert support for improving STEM education.

До каква степен получавате подкрепа от експерти извън училището, за да подобрите обучението си по STEM?  
18 отговора

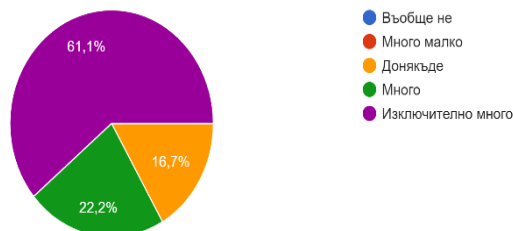


**Fig. 7** *To what extent do you receive support from experts outside the school to enhance your STEM learning?*



Regarding the question of whether innovative STEM teaching has a positive impact on students' effort to learn, more than 80% of participants (61.1% extremely, 22.2% very much) answered that there is such an impact. About 17% responded that it had some positive impact, and no one responded that innovative STEM teaching had very little or no positive impact on student motivation.

Според вас иновативното STEM преподаване (с използване на ИКТ и иновативни педагогически подходи) има ли положително въз...ите да се стараят повече в това, което учат?  
18 отговора

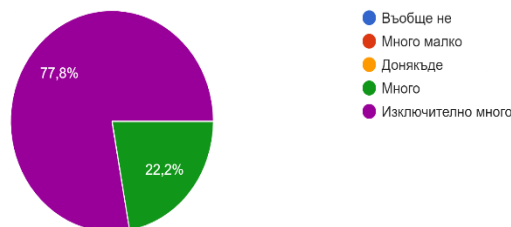


**Fig. 8** *In your opinion, does innovative STEM teaching (using ICT and innovative pedagogical approaches) have a positive impact on students working harder?*

Summarizing the results of the question "Do you think innovative STEM teaching has a positive impact on students' understanding of what they are learning?" We can conclude that 77.7% of the participants believe that innovative STEM teaching has an extremely positive impact on making students understand what they learn more easily, and 22.3% respondents believe that it has a very positive impact on attitude. None of the participants responded that innovative STEM teaching has some, very little, or no positive impact on students' understanding of what they learn more easily.



Според вас иновативното STEM преподаване (с използване на ИКТ и иновативни педагогически подходи) има ли положително въз... да разбират по-лесно това, което научават?  
18 отговора



**Fig. 9** *In your opinion, does innovative STEM teaching (using ICT and innovative pedagogical approaches) have a positive impact on making students understand what they learn more easily?*

With these answers, one can feel the pragmatic attitude of the teachers and their fatigue from the long-term superimposition of facts and formulas without real understanding. Visualization and use of the material taught are extremely important for current students.

**Based on the survey results, the following conclusions can be drawn:**

- There is an increased commitment to the studied natural science material when it is using STEM methodology;
- Student engagement increases when innovative STEM teaching is used and has an extremely positive impact on students;
- The lack of content in Bulgarian significantly complicates the development of STEM lessons for teachers;
- Summarizing the results, it can be said that although a significant part of the participants uses STEM software in teaching STEM classes, there are still quite a few teachers who do not use it or use it very rarely. This may mean that more training and resources are still needed to promote the use of STEM software in the educational process.



## Recommendations

In order to improve the state of STEM education in Bulgaria, the following recommendations are suggested:

- Improving teacher training: Government should make STEM teacher training a priority and create initiatives that attract and retain qualified STEM teachers;
- Investments in STEM education: Increased funding should be directed to STEM programs, including providing equipment, laboratories, and technology;
- Collaboration with STEM professionals: Collaboration between STEM education stakeholders, educators, and STEM professionals should be increased to provide students with insight into STEM applications across industries;
- Increased access to STEM opportunities: Government should implement initiatives that ensure equal access to STEM education opportunities for all demographic groups.

## Conclusion

STEM education is an integral part of an innovative education system and is essential to national economic growth and prosperity. By investing in teacher training, increasing funding, establishing collaborations and improving access to STEM opportunities, Bulgaria can improve its educational outcomes in STEM and prepare a skilled workforce for the twenty-first century.

## LITERATURE

Bairaktarova, D., Cox, M. F., & Evangelou, D. (2011). Leadership training in science, technology, engineering and mathematics education in Bulgaria. *European Journal of Engineering Education*, 36(6), 585-594

Breiner, Jonathan & Harkness, Shelly & Johnson, Carla & Koehler, Catherine. (2012). What is STEM? A discussion about Conceptions of STEM in education and partnerships. *School Science and Mathematics*. 112. 10.1111/j.1949-8594.2011.00109.x.

Connor, A., Karmokar, S., & Whittington, C. (2015). From STEM to STEAM: Strategies for enhancing engineering & technology education. *Int. J. Eng. Pedagog.* 5(2), 37–47.





de Jong, T. (2006). Computer simulations – technological advances in inquiry learning. *Science*, 312, 532–533. doi:10.1126/science.1127750

Graham, R., 2009. Engineering leadership education: a snapshot review of international good practices. Bernard M. Gordon MIT Engineering Leadership Program[online]. Available from: <http://web.mit.edu/gordonelp/elewhitepaper.pdf>

Grancharova, D. (2019). The three principles of mechanics. *Journal STEM in Bulgaria, Europe and the World / Magazine STEM in Bulgaria, Europe and the World (STEM - natural and engineering sciences, technologies and mathematics)* ISSN: 2682 – 9924.

<https://stem.mon.bg/project-methodology-stem-resources-description/>

<https://web.mon.bg/bg/100835>

<https://web.mon.bg/bg/101212>

[https://wp.flgr.bg/wp-content/uploads/2019/12/PISA-2018\\_First-Analysis\\_IRE.pdf](https://wp.flgr.bg/wp-content/uploads/2019/12/PISA-2018_First-Analysis_IRE.pdf)

[https://www.copuo.bg/sites/default/files/uploads/docs/2020-12/TIMSS2019\\_resultati.pdf](https://www.copuo.bg/sites/default/files/uploads/docs/2020-12/TIMSS2019_resultati.pdf)

Keselman, A. (2003). Supporting inquiry learning by promoting normative understanding of multivariable causality. *Journal of Research in Science Teaching*, 40, 898–921.

Nilson, L. B. (2010). *Teaching at its best: A research-based resource for college instructors* (2nd ed.). San Francisco, CA: Jossey-Bass

Pedaste, M., Mäeots, M., Siiman, L. A., De Jong, T., Van Riesen, S. A., Kamp, E. T., ... & Tsourlidaki, E. (2015). Phases of inquiry-based learning: Definitions and the inquiry cycle. *Educational research review*, 14, 47-61.

Peppler, Kylie & Bender, Sophia. (2013). *Maker Movement Spreads Innovation One Project at a Time*. *Phi Delta Kappan*. 95. 22-27. 10.1177/003172171309500306.

Sabirova, F., Vinogradova, M., Isaeva, A., Litvinova, T., & Kudinov, S. (2020). Professional competences in STEM education. *International Journal of Emerging Technologies in Learning (iJET)*, 15(14), 179-193



- Sanders, M. E. (2009, February 23). Integrative STEM Education for PK-12 Education. Paper presented at the Triangle Coalition Conference, Washington, DC
- Smith, Karl & Moore, Tamara. (2014). Advancing the State of the Art of STEM Integration. Journal of STEM Education. 15. 5-10.
- Terzieva, V., Paunova-Hubenova, E., Dimitrov, S., & Boneva, Y. (2020). ICT in STEM Education in Bulgaria. In The Challenges of the Digital Transformation in Education: Proceedings of the 21st International Conference on Interactive Collaborative Learning (ICL2018)-Volume 1 (pp. 801-812). Springer International Publishing
- Todorova, S. (2022). Science literacy of bulgarian students through teachers'view. Trakia Journal of Sciences, 20(3), 203.
- Wang, Hui-Hui. (2012). A new era of science education: science teachers' perceptions and classroom practices of science, technology, engineering and mathematics (STEM) integration ([www.mon.bg](http://www.mon.bg))
- Wolpert-Gawron, H. (2015). DIY project-based learning for ELA and history. Routledge. <https://doi.org/10.4324/9781315709581>.



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## THE STATE OF THE ART ANALYZE ABOUT STEM EDUCATION PRACTICES IN TURKEY

### Forefront

This report presents a comprehensive overview of the Turkish STEM Initiatives, compiled by a team of researchers with expertise in the fields of STEM Education and STEM fields.

*Prof. Dr. Eylem BAYIR*

Eylem BAYIR has been working as Prof. Dr. at Trakya University in Science Education Department and as head of the department since 2015. Her fields of research is STEM education, inquiry-based science learning, nature of science, educational games on science, professional development of science teachers. She has many national and international projects, articles and book chapters on these subjects. She was the coordinator of “Bridge from Türkiye to the World: STEM Education” project carried out with the support of the Turkish Cooperation and Coordination Agency –TIKA. She provided STEM training for teachers from seven different countries from Asia and Balkans in 2018 and 2019 in this project with her colleagues.

*Prof. Dr. ŞebnemSelen İŞBİLİR*

Sebnem SELEN ISBILIR received Ph.D. in biochemistry from Trakya University and has been working in Trakya University, Natural Science Faculty, Chemistry Department since 1998. She has been working as Professor since 2019 and head of the Department of Chemistry since 2021. Her research is focused on the antioxidant activity assays, secondary metabolites, enzyme isolation and enzyme inhibition. In particular, she studies on the obtaining plant extracts, the determination of antioxidant activity in these extracts by various methods, and the analysis of secondary metabolites such as phenolic substances, flavonoids, anthocyanins, and tannins. She took part in foundational supported projects and directed four postgraduate theses.

*Assoc. Professor Dr. Hüsnüye Durmaz*



Dr. Hüsnüye Durmaz, an associate professor and full-time researcher at Trakya University, is passionate about promoting STEM education and socio-scientific issues. His research focuses on improving science education by enhancing the professional development of science teachers and integrating innovative technologies into their lessons. He also develops hands-on and inquiry-based STEM activities for elementary and middle school students, and conducts professional development programs for teachers. Dr. Durmaz's work is essential for improving the quality of STEM education and inspiring the next generation of scientists, engineers, and innovators.

*Assoc. Professor Dr. HasanÖzyıldırım*

HasanÖzyıldırım graduated from Ege University, Faculty of Science, Department of Chemistry. After teaching at state schools for a while, he started working at the Faculty of Science at Trakya University. In this process, he completed his master's and doctorate studies in organic chemistry at Trakya University. In these studies, he mainly worked with the synthesis of polymers and organic molecules. Since 2002, he has been working as an assistant professor at Trakya University, Faculty of Education, Department of Mathematics and Science. While working at Trakya University Faculty of Education, he was interested in out-of-school learning and STEM education and made some academic studies and practices. Taking part in national and international education some projects for STEM education teachers and students, HasanÖzyıldırım still continues his chemistry and education studies.

*Assist. Professor Dr. EmrahOğuzhanDinçer*

Dr. Emrah OĞUZHAN DİNÇER is a full-time assistant professor at Trakya University who is actively engaged in researching the integration of science, mathematics, and physics teaching. Her primary focus is on assisting science teachers in incorporating technology-based teaching methodologies into their lesson plans. With a background in mechanical engineering, Dr. OĞUZHAN is well-equipped to design and implement STEM activities suitable for middle school students.

*Assist. Professor Dr. SertaçArabacıoğlu*

Dr. Sertaç Arabacıoğlu, a full-time assistant professor at Trakya University, is actively involved in promoting STEM education through various research and outreach activities. One of Dr. Arabacıoğlu's main areas of research is the continuing professional development of science teachers. He understands



that teachers play a critical role in shaping students' attitudes and interests towards STEM subjects. Dr. Arabacıoğlu is also involved in the development of STEM activities for elementary and middle school students. These activities are designed to be hands-on and inquiry-based, allowing students to explore and learn about scientific concepts in a fun and interactive way. Additionally, he organizes professional development programs for teachers, including guided teacher camps and interactive workshops. These programs enable teachers to learn new teaching techniques and share best practices with their colleagues.

Our team studied the various sources of information available to provide an in-depth analysis of the current state of STEM initiatives in Türkiye. Thus, the first step in preparing a Turkish STEM Initiatives Country Report was to identify the sources of data. And we decided various sources, including government-funded, university-led, and industry-led organizations. Additionally, we've consulted research papers published in journals indexed by Web of Science (WoS) and Türkiye (TR), as well as master's and PhD theses. We also considered STEM activity workshops, such as those held at STEM centers, science museums, and interactive exhibits.

We analyzed to identify trends and patterns, as well as challenges and opportunities in Turkish STEM initiatives by looking for common themes and patterns in the last 5th years data. The first section of the report aimed to provide a calibrated perspective on STEM education within the consortium by presenting a general approach to STEM education and reflecting the partner country's understanding of STEM education through methods and activities. The second section provides a comprehensive analysis of research reports, articles, theses, and other science and society activities related to STEM education. Finally, an overview on the challenges and opportunities awaiting the project stakeholders is presented. We hope that this report will be a valuable resource for those interested in understanding the current state of STEM initiatives in Türkiye.

*Project Coordinator*  
Prof. Dr. Eylem BAYIR



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## Index of abbreviations

Ministry of National Education (Türkiye)	MEB
Turkish Scientific and Technical Research Council	TÜBİTAK
Turkish Industry and Business Association	TUSIAD
Ministry of Development	KB
Science, technology, engineering, and math	STEM
İstanbul Aydın University (Private University)	IAU
Programme for International Student Assessment	tpacktpack
Technological Pedagogical Content Knowledge	TPACK
Information and Communication Technology	ICT



## STATE-OF-THE-ART STEM EDUCATION INITIATIVES IN TÜRKİYE

### Foundational Sources and National Context for Country Report Coverage

To foster a skilled workforce and spur economic growth, STEM education has been recognized as a crucial field of focus. In order to gain insight into the present status of STEM education in Türkiye, we have compiled information from several sources (refer to Table 1), which encompass reports from government-funded, university-led, and industry-led organizations. Moreover, we have scrutinized research papers published in journals listed in Web of Science (WoS) and Türkiye (TR) to discern patterns and trends in STEM education. We have also evaluated master's and PhD theses to gain a more profound understanding of the research in this domain. Finally, we have analyzed STEM activity workshops such as STEM centers and STEM-related interactive exhibits and workshops in Science Centers and Museums to fathom the practical experiences that are being offered to students. By combining these diverse data sources, our objective was to provide a comprehensive comprehension of STEM education in Türkiye and to identify possible areas for improvement.

**Table 1.**  
Source of data for Country Report

Sources	Number of sources
Reports	
Government-funded	7
University-led	2
Industry-led	2
Published Papers from Journals	
WoS indexed studies from Turkey Country/Region	129
TR indexed studies from Turkey Country/Region	104
Master's and PhD Thesis	230
STEM centers and workshops	
STEM centers	13
STEM-related interactive exhibits and workshops in Science Centers and Museums	7



## Reports Laying the Foundations for the Implementation and Dissemination of the STEM Approach in Türkiye

Today, it is known by everyone that science, technology, mathematics and engineering constitute the main components of the development of countries. For this reason, many countries are investing in the STEM approach, which enables future generations to grow up in these areas. In this context, some reports/documents have been prepared by MEB as the institution responsible for education, laying the foundations for the implementation and dissemination of the STEM approach in Türkiye. With the prepared reports/documents, the necessity of STEM education has been revealed by the education experts and institutions and the business world, and Türkiye's need for this approach has been brought to the agenda.

In the "Vision 2023 Strategy Document", prepared in 2004, it was stated that "Developing the creativity and imagination of the individual; observing and evaluating individual differences, each individual can develop himself at the highest level in line with his characteristics; freed from time and space constraints, created his own unique learning technologies and renewed himself with the flexibility of change. The vision in the field of education is "to have a learning and people-oriented education system that has the power to learn". At the same time, being able to dominate the technologies of the future and the fields of science that supports these technologies requires having trained manpower; and this manpower includes R&D personnel and people who have received science and engineering education in the aforementioned science and technology fields; therefore, it was stated that all levels of the education system should be taken into account in order to train people with these characteristics (Turkish Scientific and Technical Research Council [TÜBİTAK], 2004).

In 2010, "Science and Technology Human Resources Strategy Document" was published by Scientific and Technological Research Institution of Türkiye (TUBİTAK) and this document includes adding project-oriented science and technology trainings to the curriculum in primary and secondary education, increasing curiosity, raising creative and entrepreneurial mindsets; Some strategies have been determined, such as increasing the interest in scientific activities by increasing popular science activities for primary and secondary education, adding projects and popular science subjects to the curriculum of the education faculty, and disseminating R&D project competitions among primary and secondary school students (TUBİTAK, 2010).





"The Tenth Development Plan" published in 2013 is the twenty-first century; it is pointed out that it will be the century of countries that can produce new knowledge by using global knowledge, transform knowledge into economic and social benefits, integrate this process with information and communication technologies, and adopt a human-oriented development approach, in addition to raising qualified human power. In this plan, the main purpose of the education system is; It is stated that it is the training of productive and happy individuals who have developed thinking, perception and problem solving skills, have self-confidence and sense of responsibility, entrepreneurship and innovation, are prone to the use and production of science and technology, equipped with the basic knowledge and skills required by the information society (Ministry of Development[KB], 2013).

In the report titled "Demand and Expectations Research for STEM-Educated Workforce" published by the Turkish Industry and Business Association (TUSIAD) in 2014, the critical role of STEM education in the economic and technological development of countries was emphasized, and in the future, STEM education, that is, different disciplines combined. It is revealed that learned brains will be needed in the whole. It has been determined that there are differences in the contributions of those who graduated from STEM fields and those who graduated from other fields in companies. As a result of the report, it was stated that it is of great importance to make necessary reforms in the curriculum, education methods and teacher training in order to raise individuals who think creatively, innovatively, analytically and critically, and have high problem-solving skills, and that it is necessary to aim to increase STEM skills at all levels of the education system (TUSIAD, 2014).

Regarding STEM education, MEB has been involved as a national support point in the Scientix Project (the community project for science education in Europe) carried out by the European Schoolnet since 2014. Within the scope of this project, Europe-wide collaboration between STEM (science, technology, engineering and mathematics) teachers, education researchers, policy makers and other STEM education professionals is encouraged and supported. The project aims to disseminate the use of technology and good practices in science education in Europe with the teacher communities created.

The first report in Türkiye, which is one of the studies carried out for the dissemination of STEM education outside MEB, is the "STEM Education Türkiye Report" prepared in 2015 hosted by Istanbul Aydın University. In the report, the need for STEM education in Türkiye has been revealed and suggestions have been made by determining a road map for its implementation (Akgündüz et al., 2015).



With the “2015-2019 Strategic Plan” published by MEB in 2015, it started with studies on STEM education in Türkiye. It is stated in the plan that it is aimed to raise individuals who are creative, entrepreneurial, innovative, open to communication and learning, self-confident and responsible by gaining the knowledge, skills, attitudes and behaviors required by the age. In the plan, MEB has paved the way for the integration of STEM education into our education system by including strategic objectives that reveal the necessity of using STEM education, thus, studies on STEM education throughout the country have accelerated (MEB, 2015).

In 2016, MEB published the STEM education report, and an action plan was prepared that includes the issues that need to be done in order to integrate this approach into the Turkish education system and to spread it throughout the country by revealing the situation regarding STEM education. The STEM Education Action Plan was formed from the following steps: 1. Establishment of STEM Education centers, 2. Conducting STEM education research in cooperation with universities in these centers, 3. Training teachers to adopt the STEM education approach, 4. Updating the curriculum to include STEM education, 5. Creating teaching environments and providing course materials for STEM education. The report has a critical importance in the adoption and dissemination of the STEM education approach in our country. As a matter of fact, STEM education started with the Science Curriculum published by MEB in 2018. In the Science Curriculum, starting from the 4th grade, the component "Science, engineering and entrepreneurship practices" has been included in order for students to establish the connection between engineering and science and to understand the interdisciplinary interaction (MEB, 2018).

The critical role of STEM fields was also mentioned in the report titled "STEM Needs in Türkiye Towards 2023" prepared by PwC and TUSIAD in 2017, and the 'savoir abilities' of the 21st century (critical thinking and problem solving, entrepreneurship and developing cooperation between systems and people, taking initiative, effective oral and written communication, analytical skills, continuous learning, curiosity and creativity) will increase. In the report, it was emphasized that the steps required for the development of STEM education and STEM workforce should be addressed at the national policy level and supported by the public, action plans should be implemented with the cooperation of the public, education and business world, and the progress should be followed closely.

In the "2023 Education Vision" document published by MEB in 2018, it is planned to establish STEM workshops within the scope of "Design-Skill Workshops" in all schools for the development of children's interests, talents and temperaments. These workshops are defined as "workshops where



activities aiming at transforming theoretical knowledge into practice, product and innovative inventions, enabling students to see the information they learn in science, technology, engineering and mathematics courses as parts of a whole" (MEB, 2018).

In the "Integration of STEM Education into Curriculum: Workshop Report" prepared as a result of the "Workshop on the Integration of STEM Education into the Curriculum" hosted by Istanbul Aydın University in 2018, the problems raised by teachers, experts and academics regarding the integration of STEM education into the curriculum were identified and the problems were divided into 11 themes. has been collected. Suggestions for solutions to the examined problems; It is necessary to determine a state education policy for STEM education, to carry out awareness activities, to design a curriculum that focuses on the skills and process suitable for STEM education, to train teachers who will implement this program in education faculties, to increase the competencies of current teachers and to create the necessary physical, social and managerial infrastructure for STEM education. has been revealed. In the "Integration of STEM Education into Curriculum: Workshop Report" prepared as a result of the "Workshop on the Integration of STEM Education into the Curriculum" hosted by Istanbul Aydın University in 2018, the problems raised by teachers, experts and academics regarding the integration of STEM education into the curriculum were identified and the problems were divided into 11 themes. has been collected. Suggestions for solutions to the examined problems; It is necessary to determine a state education policy for STEM education, to carry out awareness activities, to design a curriculum that focuses on the skills and process suitable for STEM education, to train teachers who will implement this program in education faculties, to increase the competencies of current teachers and to create the necessary physical, social and managerial infrastructure for STEM education.



**Table 2**

Reports Laying the Foundations for the Implementation and Dissemination of the STEM Approach in Turkey

Date	Report Name	Institution Name	Emphasis on STEM Education in the Report
2004	Vision 2023 Strategy Document	TUBİTAK	As a vision in the field of education; developing 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 the constraints of time and space, it has created its own unique learning technologies and has the power to renew itself with its flexibility of change; It has been determined to have a learning and people-oriented education system.
2010	Science Technology Human Resources Strategy Document	TUBİTAK	Some strategies have been determined, such as adding project-oriented Science and Technology education to the curriculum in primary and secondary education, increasing the interest in scientific activities, making projects and adding popular science subjects to the curriculum of the education faculty, and disseminating R&D project competitions between primary and secondary school students.
2013	Tenth Development Plan	Ministry of Development	The main purpose of the education system; It is stated that it is the training of productive and happy individuals who have developed thinking, perception and problem-solving skills, have self-confidence and sense of responsibility, entrepreneurship and innovation, are prone to the use and production of science and technology, equipped with the basic knowledge and skills required by the information society.
2014	Demand and Expectations Research for STEM-Educated Workforce	TUSİAD	It has been stated that it is of great importance to make necessary reforms in the curriculum, education methods and teacher training in order to raise individuals who think creatively, innovatively, analytically and critically, and have high problem-solving skills in the education system, and it is necessary to aim to increase STEM skills at all levels of the education system.
2014	Scientix Project	MEB	The project encourages and supports Europe-wide collaboration between STEM (science, technology, engineering and mathematics) teachers, education researchers, policy makers and other STEM education professionals. The project aims to disseminate the use of technology and good practices in science education in Europe with the teacher communities created.

**Project 2022-1-BG01-KA220-HED-000088567 Green STEM model for teachers education**

~~Co-funded by the European Union Erasmus+ KA220-HED - Cooperation partnerships in higher education~~

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**Table 2. Continue**

Reports Laying the Foundations for the Implementation and Dissemination of the STEM Approach in Turkey

Date	Report Name	Institution Name	Emphasis on STEM Education in the Report
2015	2015-2019 Strategic Plan	MEB	It is stated in the plan that it is aimed to raise individuals who are entrepreneurial, innovative, creative, open to communication and learning, self-confident and responsible by gaining the knowledge, skills, attitudes and behaviors required by the age.
2015	STEM Education Turkey Report	IAU	In the report, the need for STEM education in Turkey has been revealed and suggestions have been made by determining the road map for its implementation.
2016	STEM Education Report	MEB	The situation regarding STEM education in our country has been revealed, and a STEM Education Action Plan has been presented in order to integrate STEM education into the education system in Turkey.
2017	Towards 2023 STEM Requirements in Turkey Report	PwC & TUSIAD	The critical role of STEM fields was mentioned, and it was emphasized that the steps required for the development of STEM education and STEM workforce should be addressed at the national policy level and supported by the public, action plans should be implemented with the cooperation of the public, education and business world, and progress should be followed closely.
2018	2023 Education Vision	MEB	It is planned to establish STEM workshops within the scope of "Design-Skill Workshops" in all schools for the development of children's interests, talents and temperaments.
2018	Integration of STEM Education into the Curriculum: Workshop Report	IAU	Problems raised regarding the integration of STEM education into the curriculum have been identified and solutions have been proposed for the problems examined.



## Situation of STEM Approach in Curriculum in Türkiye

Compared to PISA 2015, Türkiye significantly increased its performance in all three areas (reading skills, mathematical literacy, science literacy) in PISA 2018 (MEB, 2019). Despite this increase, it does not rank high enough. It is possible to say that it is important for Türkiye to reach the desired level in the international PISA exams by adopting the STEM approach and integrating it into the curriculum.

Integrating STEM into curricula at all levels from pre-school to university is of great importance for the spread of STEM. STEM-integrated curricula will enable students to use different disciplines together to solve problems encountered in daily life, enabling meaningful learning to take place (Aydeniz, 2017; Beane, 1995; Czerniak, Weber, Gonzalez&Kuenzi, 1999; Cerniak, et al., 1999; Yıldırım & Altun, 2015).

From this point of view, as it can be understood from what is explained below, studies have started and are continuing with the integration of the STEM approach into the curricula at all education levels in Türkiye.

### Situation of STEM Approach in Preschool Curriculum:

The current program as a pre-school education program in Türkiye is the 2013 Pre-School Education Program prepared in 2013. Although there is no direct emphasis on STEM education in this program, the achievements and indicators belonging to all development areas, primarily the acquisitions and indicators related to cognitive development, can be easily associated with STEM education. It has been revealed that the achievements in the Education Program are related, include basic ideas and concepts related to STEM education, and have most of the features of STEM education (AtaDemircan, Şenyurt, & Çetin, 2017). In this respect, the program is suitable for STEM education.

It is also known that MEB, private education institutions and universities and NGOs carry out educational activities, fairs, competitions, curriculum development and implementation activities regarding the STEM approach in pre-school education in Türkiye (Polat and Bardak, 2019).

Some universities in Türkiye (such as METU, YTU, Bahçeşehir) organize trainings for preschool teachers such as STEM Workshop, STEM Trainer's Education Program, Early Childhood STEM Education, and it is aimed to raise awareness in preschool teachers and to have knowledge about practices.



### Situation of STEM Approach in Primary/MiddleSchoolCurriculum:

The regulations regarding the integration of the STEM approach in the curricula in Türkiye are particularly striking in the science curriculum.

Although not under the name of STEM approach in the Science and Technology Curriculum prepared in Türkiye in 2005, the existence of issues such as "Science-Technology-Society-Environment Relationship", "Technological Design Cycle and Entrepreneurship" can be considered as a start for the implementation of the STEM approach.

In the "STEM Education Report" prepared by MEB in 2016, the necessity of STEM education was emphasized in the curriculum, and this emphasis was included in the report as follows: The examination system should be shaped accordingly, and students' high-level skills such as questioning, research, product development and invention should be highlighted. Science laboratories in schools should be reorganized and provided in accordance with STEM education." (MEB, 2016). In the classrooms, STEM applications were included as the last unit, under the name of "Applied Science", accompanied by the achievements that correspond to the steps of the engineering design process.

With the update made in the Science Curriculum in 2018, it was shown that the STEM approach was adopted by giving the "Science, Engineering and Entrepreneurship Practices" as covering all the units, although the name "STEM" was not clearly stated. In addition, the explanation regarding the application of the STEM approach in the program is as follows: "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. In solving the problem, students compare alternative solutions and choose the appropriate one within the scope of the criteria. By planning for the chosen solution, they are expected to present and present the product at the next stage. The design and production process of the product is carried out in the school environment. Students are expected to make experiments during the product development phase, record the qualitative and quantitative data they have obtained as a result of these trials, and evaluate them with their ability to read or create graphs.





They are asked to create strategies and use promotional tools to market the product in order to develop entrepreneurial skills. For example, students can prepare newspaper, internet, television advertisements or shoot short films for promotional purposes.” (MEB 2018).

### Situation of STEM Approach in Secondary School Curriculum:

Although STEM approach is not mentioned at all in the education programs of STEM courses (Physics, Chemistry, Biology, Mathematics and Computer Science), it has been determined that the applications of the STEM approach are either not included in the purchases or they are given little or no place (Karabolat, Atıcı & Taflı) , 2021; curriculum.meb.gov.tr).

### Status in the University/Faculty of Education Curriculum:

The support and contributions of universities in Türkiye towards the implementation of the STEM approach have been increasing in recent years. Within the scope of this context, universities conduct various activities such as arranging trainers' trainings via application and research centers, integrating compulsory or optional STEM courses into their curricula, organizing symposiums, congresses, and workshops, as well as undertaking diverse scientific studies and projects (MEB, 2016). The links provided below offer noteworthy instances of these activities:

- 4th International STEM Education Conference: <https://www.stempd.net/>
- Hacettepe STEM & Maker Lab: <https://hstem.hacettepe.edu.tr>
- BİLTEM Center for Science Technology Engineering and Mathematics Education: <https://biltemm.metu.edu.tr/tr>
- Muğla Sıtkı Koçman University Science Education Research & Application Center <https://mubem.mu.edu.tr/tr>

Especially education faculties have an important place because they train teachers who will apply the STEM approach, and the teachers who are responsible for applying the STEM education approach provide academic support through in-service training. It is absolutely necessary to include courses in the curricula of education faculties that will enable teacher candidates to be trained to have STEM-related field knowledge, field education knowledge, and STEM application competencies.





In Türkiye, education faculties undergraduate curricula were updated in 2018, and when the course names and course contents in teacher training undergraduate programs related to STEM fields are examined (Science Education, Elementary Mathematics Teaching, Computer and Instructional Technologies Teaching, Physics Teaching, Chemistry Teaching, Biology Teaching, It is seen that there are no courses related to direct STEM education in the programs (Türk, 2019; yok.gov.tr). However, it has been determined that in the curricula of Science and Primary School Mathematics Teaching departments, there is a course for associating the department field with other fields (Interdisciplinary Science Teaching, Relation in Mathematics Teaching). However, it has been determined that these courses are theoretical courses for 2 or 3 hours.

It is known that no undergraduate or graduate education programs related to STEM have been opened in any education faculties in Türkiye (Çolakoğlu & Günay Gökben, 2017).

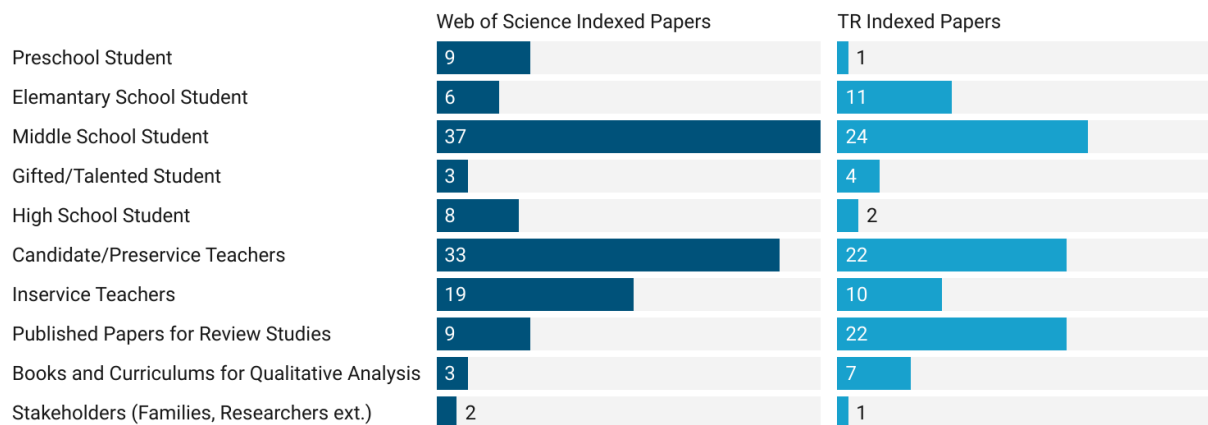
This situation reveals the necessity of opening courses that are directly related to STEM education and including applications in undergraduate programs of education faculties, as well as postgraduate education programs and designing curricula for these courses.



## State-of-the Art Research Initiatives in the Web of Science (WoS) and TR-Indexed Papers

In this analysis, we examined 226 papers on STEM education that were indexed in WoS and TR. Our extraction criteria involved searching for articles that were conducted in Turkish universities, schools, and other institutions. We collected all the relevant papers related to STEM education trends in Türkiye from WoS and TR indexed sources to ensure that the data was comprehensive and inclusive. Other scopes were excluded. Next, we organized the collected papers by creating a spreadsheet or database that contained important details such as the title, purpose, methodologies, participants, and results of each paper. This step may have required data cleaning and formatting to ensure consistency. We also carried out necessary transformations to standardize the coding structure. To analyze the data, we identified patterns, trends, and relationships among the papers. This involved summarizing the key findings of each paper and categorizing them into relevant codes or categories. Figure 1 summarizes the sources of data and participants of the published papers analyzed in the country report.

### Participant/data source-based categorization of examined publications from two indexes



*Note.* The International Standard Classification of Education (ISCED) system, recognized by the United Nations Educational, Scientific, and Cultural Organization (UNESCO), classifies education as preschool, elementary, middle, and high school students, which are used to categorize different school levels in studies. It is important to consider that a study may involve multiple groups of participants.

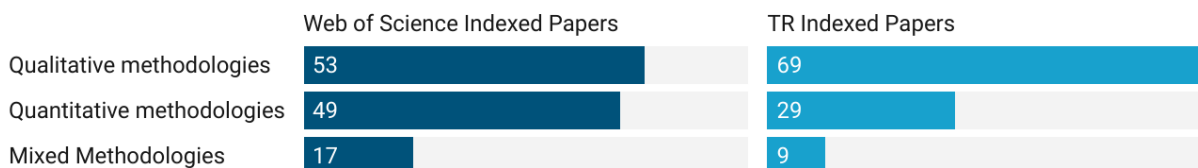
**Figure 1.**

Sources of Data & Participants of Published Papers Analyzed in Country Report



Figure 2 depicts the analyzed papers and their respective methodologies that were indexed.

## Methodology-based categorization of examined publications from two indexes



**Figure 2.**

Methodologies of Published Papers Analyzed in Country Report

The study involved various groups of participants, including students and teachers, and analyzed 226 articles indexed in WoS and TR that explored STEM education trends in Türkiye. The findings, presented through descriptive patterns for each participant group, offer insights into the different approaches to STEM education in the country.

### Research Trends and Patterns Involving Student Participation: Sampling from Preschool, elementary, middle, and high schools

#### *Studies with preschool students:*

According to the state-of-the-art studies, early exposure to **STEM activities** can help children develop an interest in science, technology, engineering, and math, which can inspire them to pursue careers in these fields in the future and help them develop a better understanding of engineering concepts (Akpınar & Akgunduz, 2022). Furthermore, **STEM activities** often involve problem-solving, which can help preschoolers develop critical thinking skills and learn how to approach challenges in a logical and systematic way (Bapoğlu Dümenci et al., 2021; Malcok & Ceylan, 2022). In addition, **STEM activities** can also encourage creativity and innovation, as children explore different solutions to problems and use their imagination to design and build things (Uret & Ceylan, 2021). Thus, studies emphasize the significance of incorporating **design thinking** in STEM education for preschoolers to stimulate the development of 21st century skills (Yalcin, 2022).



Studies also gives a better understanding about the perspectives and experiences of preschoolers. For example, studies have emphasized the importance of comprehending preschoolers' viewpoints and encounters regarding **engineering design-oriented STEM tasks** concerning the concepts of science, like forces, floating/sinking (Ata-Akturk, 2023), as well as images of **engineers and engineering** (Ata-Akturk & Demircan, 2022). In addition, educators and researchers have reported their observations from particular **STEM activities** in a more comprehensive manner, including but not limited to, egg-carrying without breakage (Ulay & Aktas, 2020), the realm of machinery (Abanoz & Yabas, 2022), and Makey-Makey programming and robotics activities (Tanik Onal & Saylan Kirmizigul, 2022).

### *Studies with elementary students:*

Various studies have been conducted on elementary school students, resulting in different research outcomes. For instance, Akar and Yadigaroglu (2021), Bircan and Calisici (2022), Yetkin and Aküzüm (2022), and Pekmez et al. (2018) focused on **the impact of STEM activities** on students' attitudes towards STEM, related skills, and academic achievements. Moreover, Cetin et al., (2020) researched young children's preferences on STEM activities based on gender, whereas another group of studies examined **students' creativity, career choices, and perceptions of engineers and engineering**, such as Azgın and Şenler (2019), Çil and Özlen (2019), and Gülhan and Şahin (2018). Sisman et al. (2021) investigated the effectiveness of robotics training on **children's spatial ability** and attitude towards STEM, and various approaches were also examined, including **out-of-school STEM workshops** (Timur et al., 2020), STEM activities in free activity course (Yaşlık & Akçay, 2022), **biomimicry-based STEM activities** (Savran Gencer et al., 2020), **Ethno-STEM Approach** (Basaran & Erol, 2023), and **aesthetics in nature through STEM and STEAM education** (Reffiane et al., 2021), all of which were aimed at elementary school students.

### *Studies with middle school students:*

Upon analyzing the state of the art of STEM studies conducted with middle school students in TÜRKİYE, it becomes evident that various activities could incite STEM education in diverse manners. For example, STEM activities in schools allow students to **develop a range of views and attitudes towards in science, technology, engineering, and math** (Akçapınar & Coşgun, 2019; Ayaz et al., 2020; Aydın & Karslı, 2019; Ceylan & Karahan, 2021; Dönmez, 2020; Ertem Akbaş et al., 2019; Pişkin Tunç & Gündoğdu, 2022). By



engaging in STEM activities, students can **develop a deeper interest and understanding of STEM fields** and can be inspired to pursue further studies in these areas (Dedetürk et al., 2021; Higde & Aktamis, 2022; Ozcan & Koca, 2019; Tozlu et al., 2019). These activities often involved inquiry-based, project-based learning and problem-solving, which can help to build critical thinking and analytical skills (Bahşi & Açıkgül Fırat, 2020; Celik, 2022; Gülen & Yaman, 2018; Higde & Aktamis, 2022; Nağaç & Kalaycı, 2021).

Moreover, **Design-based STEM education** emphasizes the use of design processes to develop solutions to real-world problems. By engaging in design activities, students can **develop critical thinking and creativity skills, entrepreneurship and career choices and interest** (Delen & Sen, 2023; Gencer & Dogan, 2020; Kirkic & Uludag, 2021; Meral & Altun Yalçın, 2022; Sarıgül & Çınar, 2021; Savran Gencer & Doğan, 2020; Yazıcı et al., 2022). The use of **technology and tools like 3D printers** can help to make the design and engineering process more engaging and accessible to students (Sen et al., 2020). Furthermore, **Engineering-oriented STEM activities** also allow students to explore concepts related to civil, mechanical, and electrical engineering (Aydoğan & Cakiroğlu, 2022; Johnston et al., 2019). By **engaging in engineering activities**, middle school students can develop skills in problem-solving, critical and computational thinking, and creativity (Ergun & Balçın, 2019; Ince & Koc, 2021). These skills are essential for interest in many STEM fields, including engineering, architecture, and construction (Balçın & Ergun, 2019; Ozkul & Ozden, 2020).

**The studies on robotics, as well as coding and programming education** provides hands-on learning opportunities for students to explore engineering and programming concepts (Akkaş et al., 2020; Cakir & Guven, 2019; Korkmaz et al., 2019). By engaging in STEM robotics activities, students can **develop skills in coding, mechanical engineering, and electronics, as well as perception, creativity and attitudes** (Adsay et al., 2020; Bolatlı & Korucu, 2018; Guven et al., 2022; Kutlu & Bakırcı, 2022; Ucgul & Altıok, 2022). These skills are essential for interest in many STEM career, including robotics, automation, and manufacturing. Furthermore, **game-based STEM design activities** with middle school students could help to promote interest in computer science and programming (Cakir et al., 2021). By engaging in game design, students could **develop skills in coding, storytelling, visual design and also deeper understanding on science topics** (Hacıoğlu & Donmez Usta, 2020). These skills are essential for many STEM fields, including game development, virtual reality, and graphic design.

**STEM-based environmental activities** can help to promote interest in environmental science and sustainability. By engaging in these activities, students can develop skills in biology, chemistry, and



environmental engineering(Erkol et al., 2022; Öztürk&Özdemir, 2020; Uslu & Yaman, 2021). **Biomimicry activities** allow students to explore how natural systems can inspire engineering solutions to real-world problems(CanbazogluBilici et al., 2021; Gencer et al., 2020). Additionally, **out-of-School STEM Education Studies and Programs** provide opportunities for students to explore STEM fields outside of traditional classroom settings. These programs, like **robotic camps**,can offer hands-on, project-based activities that foster interest and engagement in STEM fields(Ucgul & Altiok, 2022). By offering exposure to **out-of-schoolSTEM programs**, these programs can help to promote interest in STEM-related careers, motivations and metacognitive awareness(Baran et al., 2019; Çevik & Abdioglu,2018).

In addition, **studies onSTE(A)M education** emphasizes the integration of arts and design into STEM fields. By engaging in STEAM activities, students can develop creativity, critical thinking, and problem-solving skills(Bati et al., 2018; N. A. Cakir et al., 2021; Ozkan & Topsakal, 2021; Ozkan & Umdutopsakal, 2021). This interdisciplinary approach can help to promote interest in STEM fields among students who may not have been interested in these subjects before.

### *Studies with high school students:*

High school students have been the subject of numerous studies on STEM education. For instance, Donmez (2021)and Karamustafaoglu & Pektas (2022)conducted studies to investigate how **out-of-school STEM activities** can influence students' career choices and creative problem-solving skills. These studies often use **inquiry-based or project-based learning environments** to enhance academic achievement and career interests, particularly in **vocational high schools**(Cevik, 2018).

Moreover, other studies have focused on the **engineering design process**(Guenilir & Olcay, 2019), utilizingstudents' **engineeringskills**(Yuceler et al., 2020), andinnovativetechnology-supportedapplications(Kumas, 2021) at thislevel. Through such studies, it has been demonstrated thathighschoolstudentsgenerallyhavemotivationandpositiveattitudetowards STEM education (Gok, 2021; Kizilay et al., 2019; Yerdelen-damar et al., 2021).

### Research Trends and Patterns Involving Preservice Teacher Participation: Sampling from Education Faculties





Preservice teachers play a crucial role in shaping the future of STEM education. To ensure they are well-equipped to teach STEM subjects, studies have been carried out to explore the **effects of various STEM activities on their knowledge, skills, and attitudes**. For instance, studies by Timur and Belek (2020), Yorulmaz and Okulu (2022), and Uğraş and Genç (2018) have focused on the impact of STEM activities on candidates' beliefs and STEM intention. Numerous studies have also been conducted to investigate prospective teachers' **perceptions and awareness of STEM education** (Acar et al., 2020; Akgün & Türel, 2021; Koyunlu Ünlü & Dere, 2019). Another study examined the development of computational thinking skills among preservice teachers (Gunbatar & Bakirci, 2019). Additionally, studies by Çakır and Altun (2021), and Özçakır Sumen and Calisici (2022) shed light on the relationship between STEM activities and academic achievement, problem-solving skills, and STEM awareness. Yildirim and Sidekli (2018), on the other hand, explored the link between STEM activities and self-efficacy and TPACK understanding. Kacan and Sahin, (2018) and Özçakır Sümen and Çalışıcı, (2019) examined the development of creative thinking and project development skills, while Alan et al., (2019) and Z. Cakir & Yalcin, (2022) studied the impact of STEM activities on lifelong learning and integrated teaching knowledge. Furthermore, studies have also looked into preservice teachers' **behavior towards technology and STEM education**. Gul and Ates (2022), for example, explored the factors that influence preservice teachers' acceptance of technology, while Aciksoz et al., (2020) investigated the relationship between STEM value-expectancy. Studies have focused on understanding **the views and attitudes of candidate teachers towards STEM education** (Hiçde et al., 2020; Yorulmaz & Okulu, 2022), as well as their understanding about STEM practices (Arslanhan & İnaltekin, 2020; Aydın et al., 2021; Üre & Çoramık, 2020). For instance, Ciftci et al., (2022) examined preservice teachers' views on STEM education, while Kartal and Tasdemir, (2021) explored their attitudes towards STEM. Meanwhile, Buyukdede and Tanel (2019) investigated prospective teachers' opinions on the effectiveness of STEM activities.

STEM education has become increasingly important as the job market continues to shift towards careers in **engineering and other design-based fields**. To ensure that students are well-prepared for these careers, it is essential that pre-service teachers are equipped with the necessary skills to effectively teach STEM subjects. This has led to numerous studies that focus on the impact of different teaching methods on preservice teachers' perceptions of STEM education. For example, Ergun and Kiyici (2019) and Özkızılcık and Betül Cebesoy (2020), as well as Kuvac and Koc (2022), have examined the effect of **design-based applications** on students' perceptions of engineering education and engineering as a



profession. Similarly, Guleryuz and Dilber, (2022) have investigated the impact of engaging students in **robotic coding and 3D visualization** on their academic success and interest in STEM careers. Other studies have focused on the effects of STEM-focused practical activities on various skills. (Sari, Celik, et al., 2022) have looked at the impact of **Arduino-based activities** on problem-solving and entrepreneurship skills, while Sari, Pektas, et al., (2022) have investigated the development of **algorithmic thinking skills** through physical computing activities with Arduino in STEM education. Finally, some studies have explored the use of media and technology to enhance STEM education, such as Ata and Cevik's (2020) research on the role of **computational thinking skills** in STEM awareness, and Ciftci and Topcu (2022) investigation of the impact of teaching self-efficacy beliefs in **computational thinking** in a STEM course. Alan et al. (2022) also have examined prospective science teachers' scientific processes while they use **Algodoo in their STEM practices**. These studies collectively demonstrate the value of STEM education and the importance of pre-service teachers being equipped with the necessary skills to effectively teach STEM subjects.

Several **qualitative studies** have been conducted to examine the development of pre-service teachers' knowledge and understanding of STEM education. One group of studies focused on investigating the STEM conceptions of pre-service teachers (Aydin-Gunbatar et al., 2021; Koyunlu Ünlü & Dere, 2018), their pedagogical content knowledge (Aydin-Gunbatar et al., 2020), STEM-focused lesson planning (Altan & Ucuncuoglu, 2019; Bozan & Kaya-capocci, 2022; Ürek & Çoramık, 2020), and views on robotic and STEM-based learning environments (Delen & Uzun, 2018; Tekerek et al., 2023; Yüksel, 2022). Another set of studies aimed to gain a better understanding of the influence of a design-based elective STEM course on pre-service teachers' content knowledge, STEM conceptions, and engineering views (Aydin-Gunbatar et al., 2018), as well as the integration of engineering into STEM lessons (Gunbatar et al., 2022; Kınık Topalsan, 2018; Tekerek & Tekerek, 2018). Additional studies explored the use of virtual reality technologies in STEM education through the perceptions of ICT pre-service teachers (Coban et al., 2020), and a redesigned online ICT course using TPACK for STEM pre-service teachers (Umutlu, 2022). Through these studies, we gain a better understanding of the effects of STEM activities on preservice teachers' knowledge, skills, attitudes, and behavior towards STEM education. This knowledge can help in the development of effective STEM teacher training programs and ultimately, enhance the quality of STEM education for future generations.





## Research Trends and Patterns Involving Inservice Teacher Participation: Sampling from Teachers Working in the School Districts

There is a limited number of studies on STEM education carried out with in-service teachers compared to teacher candidates. However, some studies have been conducted **to understand the perceptions, views, and awareness of in-service teachers** regarding STEM education (Acıksoz et al., 2020; Çınar & Terzi, 2021; Çolak & Buldur, 2022; Karademir Coşkun et al., 2020; Özcan & Koştur, 2018). Workshops are commonly used as a professional development approach for in-service teachers in STEM education. Several studies have examined teachers' perceptions of STEM applications, including Altun and Apaydın (2022), Yucelyigit, (2021) and Yildirim et al., (2022).

In addition, **specific training programs** have been developed for STEM education, such as STEM focused professional development (Bozan, & Anagün, 2019), the mentorship model (Yabaş & Boyacı, 2022; Yabas & Bozoglu, 2022) and the STEM teacher institute training model (Yildirim, 2020). Interdisciplinary activities are also used to integrate computational thinking into STEM activities. Ozdinc et al., (2022) presented an unplugged programming activity for this purpose. Moreover, Aykan and Yildirim (2022) introduced the Lesson Study Model into Distance STEM Education. Furthermore, parent involvement in early engineering education was investigated by Ata-Akturk & Demircan (2021), while MOOCs in STEM education were studied by Yildirim (2022).

Another group of studies focused on **understanding in-service teachers' STEM classroom practices**. Aydın (2020) examined prerequisites for elementary school teachers before practicing STEM education, Demircan, (2022) determined preschool teachers' perspectives regarding integrative STEM practices, and Tezcan Şirin et al (2022) examined STEM activities in school science textbooks. Similarly, Preschool teachers' and middle school science teachers preparation and views were investigated by Ata and Arslan (2021) and Yildirim (2021), while Aydogdu et al., (2020) examined the change in perceptions of science teachers about E-STEM. Mumcu et al. (2023) and Durak et al. (2022) investigated teachers' views on computational thinking through design-based or art-integrated practices.



## State-of-the Art Research Initiatives in Master Thesis & Doctoral Dissertations

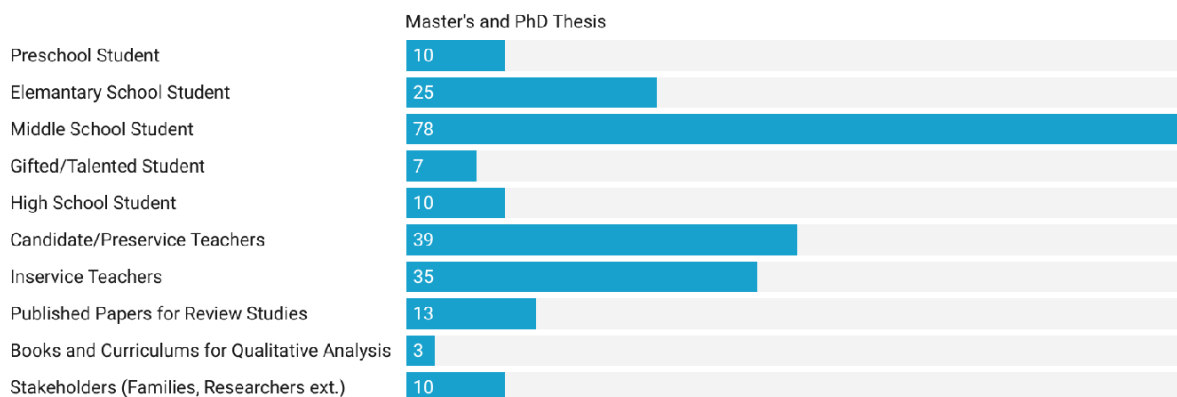
Initially, our team's focus was to examine the prevailing trends, challenges, and best practices in STEM education. To achieve this, we analyzed 230 Master's and PhD theses published within the last 5 years. Subsequently, we set the scope of our analysis to cover the last 5 years (2018-2023) and specifically targeted the theses published in Turkish Thesis Center (YÖK Tez) and carried out in Türkiye Universities. All of the selected theses had STEM education as their main topic.

We developed a search strategy that involved identifying relevant keywords and their synonyms for STEM education, such as Science, Technology, Engineering, Mathematics, STEM education, STEM teaching, STEM learning, STEM curriculum, STEM pedagogy, and STEM assessment. We only used official thesis databases (YÖK Thesis) to conduct the search and extracted pertinent information from the selected theses, such as research objectives, methods, findings, and participants. We then organized the collected data in a spreadsheet or database for convenient analysis. Our team performed a descriptive analysis of the collected data, including the frequency of STEM education topics, research methods used, and participants involved. Additionally, we conducted an analysis of the various topics addressed in the studies. The main findings of our analysis are presented in Figure 3.

The evaluation of STEM Education Master's and PhD Theses has concluded, comprising a total of 230 theses. These theses encompassed 10 preschool students, 25 elementary school students, 78 middle school students, 7 gifted/talented students, and 10 high school students. In addition, 39 prospective/preservice teachers and 35 active teachers took part in the study. Moreover, 13 published articles, 3 books, and curriculums were scrutinized for qualitative analysis. The analysis also involved 10 stakeholders, such as families and researchers. Individuals can access data files, and analysed the sis through the Open Science Framework website ([https://osf.io/mcyv7/?view\\_only=2d17fc24b6974a20a945a49c6a21bf71](https://osf.io/mcyv7/?view_only=2d17fc24b6974a20a945a49c6a21bf71)).



### Sources of Data & Participants of Thesis Analyzed in Country Report



**Figure 3.**

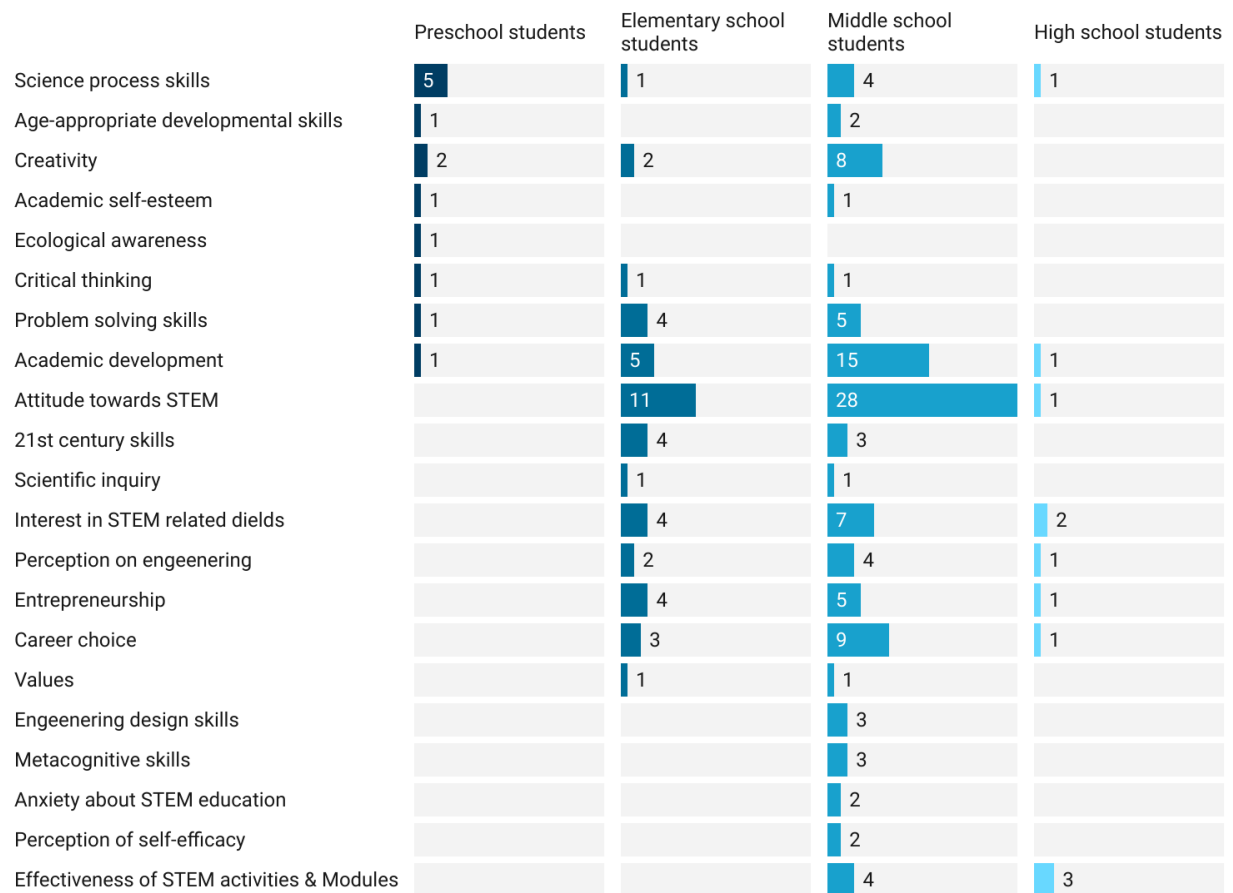
Sources of Data & Participants of Thesis Analyzed in Country Report

The analyzed thesis emphasizes various developmental aspects in preschool children, as revealed by the frequency data presented in Figure 4. The table comprises eight distinct topics, each assigned a frequency score of either 1 or 5. The first topic, science process skills, refers to the capacity of preschool children to comprehend and apply scientific principles and methodologies. The second topic, age-appropriate developmental skills, pertains to the acquisition of skills typically observed in preschoolers, such as social skills, language development, and gross and fine motor skills. Creativity is the third topic, indicating the ability of preschoolers to express themselves through art and imaginative play. The remaining topics relate to different areas of academic development, such as academic self-esteem, critical thinking, problem-solving skills, and academic progress. These topics are critical for preschool children as they lay the groundwork for their future academic success and lifelong learning. Taken together, the frequency table suggests that the analyzed thesis focuses on a wide range of developmental domains in preschool children, including science, creativity, and academic skills.

Moreover, based on the frequency table provided, it appears that the analyzed thesis focuses on a range of topics related to the development and education of elementary school students. The table includes 12 different topics, each of which has a frequency ranging from 1 to 11, suggesting that the thesis covers a variety of themes with varying levels of importance. The most frequently occurring topic in the table is attitude towards STEM, with a frequency of 11.



## Topics for STEM Education Examined in Master's and PhD Theses



**Figure 4.**

### Topics of Thesis Analyzed in Country Report

This suggests that the theses are primarily focused on exploring how students' attitudes towards science, technology, engineering, and math impact their academic and career aspirations. Understanding students' perceptions of STEM fields is crucial for educators, as it can inform curriculum development and teaching strategies. In addition to attitude towards STEM, the frequency table reveals several other important topics related to academic and personal development. Academic development has a frequency of 5, indicating that the thesis likely explores the academic skills and abilities of elementary school students. Problem solving skills, 21st century skills, interest in STEM related fields, and entrepreneurship all have frequencies of 4, suggesting that the thesis may delve into the ways in which these skills and interests can be fostered in elementary school students. Creativity and critical thinking, both with a



frequency of 2, may be areas of focus for the thesis in terms of developing students' ability to approach problems in new and innovative ways. Perception on engineering, career choice, and values, all with frequencies of 1, suggest that the thesis are explore these topics in less depth but still touch on their importance for elementary school students. Overall, the frequency table indicates that the analyzed thesis explores a wide range of topics related to the development and education of elementary school students, with a particular emphasis on STEM-related fields and skills. By examining the topics, strategies for cultivating students' academic and personal growth, as well as their interest and engagement in STEM fields.

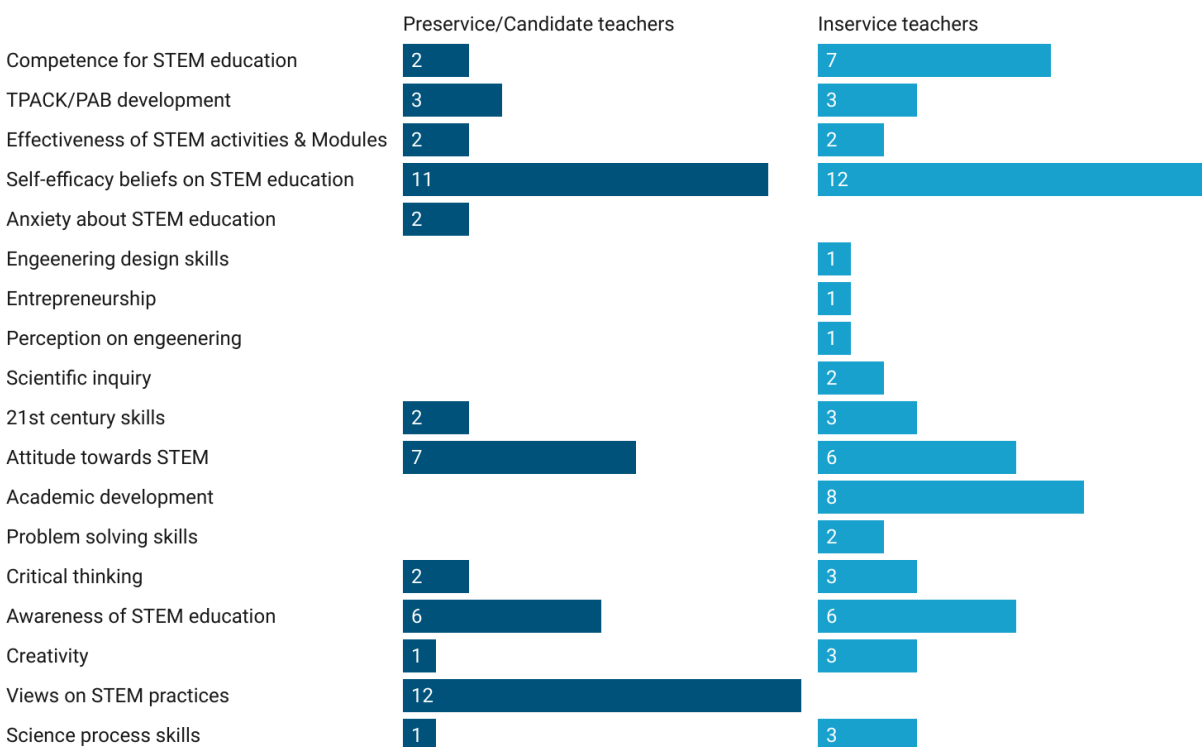
Furthermore, Figure 4 provided covers a range of topics related to middle school students and their attitudes, skills, and perceptions towards STEM education. The table shows that the most frequently mentioned topic is "attitude towards STEM," which was mentioned 28 times. This suggests that researchers and educators are interested in understanding how middle school students perceive STEM subjects and how they feel about them. Other notable topics that were mentioned multiple times include "academic development" (15), "career choice" (9), "creativity" (8), and "interest in STEM-related fields" (7). These topics suggest that there is a focus on understanding how to engage middle school students in STEM subjects and how to encourage them to pursue careers in STEM-related fields. In addition, there are several topics that were only mentioned once or a few times, such as "academic self-esteem," "critical thinking," and "scientific inquiry." These topics highlight the importance of developing specific skills and attitudes that are necessary for success in STEM subjects. Overall, the frequency table provides a broad overview of the different topics that researchers and educators are interested in exploring related to middle school students and STEM education. These topics can help guide future research and program development aimed at improving STEM education and increasing student engagement and success in STEM subjects.

In addition, the Figure 4 presented includes several topics related to STEM education among high school students. One of the most prominent themes is the interest in STEM-related fields, which was ranked with a frequency of 2. This suggests that students in high school have a significant interest in pursuing careers or fields of study related to science, technology, engineering, and mathematics. Another topic that is relevant to STEM education is the effectiveness of STEM activities and modules, which was rated with a frequency of 3. Attitude towards STEM and perception of engineering were rated with a frequency of 1 each, suggesting that there is room for improvement in these areas. It is important



to explore the reasons why students could have negative attitudes towards STEM or engineering and develop strategies to address these issues. Academic development, entrepreneurship, and career choice were also rated with a frequency of 1 each. These topics are all important for students' success in the STEM fields, as they relate to developing the skills and knowledge needed to succeed in these areas. Overall, this frequency table provides valuable insights into the current state of STEM education among high school students.

### Topics for STEM Education Examined in Master's and PhD theses



**Figure 5**

Topics of Thesis Analyzed in Country Report (Sampled from Preservice & Inservice Teachers)

Figure 5 presents the topics analyzed in a thesis on Preservice/Candidate teachers. The table indicates the number of times each topic was mentioned in the thesis. Based on the table, it appears that the thesis focused more on the candidates' views and awareness of STEM practices, as well as their self-efficacy beliefs on STEM education. These topics were mentioned 12 and 11 times, respectively. The candidates' attitudes towards STEM education and their competence for STEM education were also discussed in the thesis, with 7 and 2 mentions, respectively. The low frequency of mentions for creativity, critical thinking, 21st-century skills, anxiety about STEM education, and effectiveness of STEM activities &



modules in dicatethat these topics were not the primary focus of thethesis.The findings suggest that the thesis primarily focused on exploring the candidates' views, awareness, and self-efficacybeliefs on STEM education. The thesis likely aimed tounders tand the candidates' perceptions of STEM educationan did entify ways to improve their preparation for teaching STEM subjects. Overall, the topics analyzed in the thesis reflect the importance of STEM education and the need to equip teachers with the necessary knowledge, skills, and attitudes to effectively teach STEM subjects. Therresults of the thesis could be used to inform teacher training programs and curriculum development to better prepare candidates for teaching STEM subjects.

Inaddition, Figure 5 provides a quick overview of the various topics analysed in the thesis related to inservice teachers. From the table, it is evident that self-efficacy beliefs on STEM education and academic development are the most frequently analysed topics, with 12 and 8 occurrences respectively.STEM education is a rapidly evolving field, and the topics covered in this thesis highlight the skills, competencies, and attitudes that are essential for inservice teachers to effectively teach STEM subjects to their students. The high frequency of topics related to STEM education, such as awareness of STEM education, attitude towards STEM, competence for STEM education, and TPACK/PAB development, highlights the importance of addressing these areas in inservice teacher training programs.The topics of creativity, critical thinking, 21st century skills, science process skills, and problem-solving skills are also frequently analysed in the thesis. These skills are essential for students to develop in order to succeed in STEM fields, and it is important for inservice teachers to possess these skills themselves to effectively teach them to their students.The low frequency of certain topics, such as perception on engineering, entrepreneurship, andengineeringdesignskills, couldindicatethatfurtherresearch is needed in these areas to fully understand their relevance to inservice teacher training programs.Overall, the topics analysed in this thesis highlight the importance of developing the skills, attitudes, and competencies necessary for inservice teachers to effectively teach STEM subjects to their students.





## State-of-the-art STEM centers& STEM-related interactive exhibits and workshops in Science Centers and Museums

STEM centers play a crucial role in Türkiye STEM education initiatives by promoting, supporting, and providing resources for STEM education. STEM centers are typically established within universities, research institutions, or other organizations and work to enhance the quality of STEM education (Table 3). Some of the roles of STEM centers in Türkiye STEM education initiatives include:

1. Developing and implementing STEM education: STEM centers develop and implement STEM activities that are aligned with national standards and provide opportunities for hands-on learning.
2. Training and professional development for teachers: STEM centers provide training and PD for teachers to improve their knowledge and skills in teaching STEM subjects.
3. Providing STEM resources: STEM centers provide a range of resources such as books, journals, software, and hardware for use by students and teachers.
4. Supporting research: STEM centers support research in STEM education to develop evidence-based approaches to teaching and learning.
5. Collaborating with industry: STEM centers collaborate with industry partners to provide opportunities for students to engage in real-world STEM experiences and learn about STEM careers.

Many critical and pioneering steps have been taken towards the establishment of STEM centers in Türkiye. For example, In June 2016, MEB emphasized the significance of establishing STEM centers in its report on STEM education. The report included a framework for the STEM education action plan, which highlighted the following objectives: setting up STEM education centers, conducting STEM research in collaboration with universities, training teachers in STEM education approaches, updating curricula to integrate STEM education, and creating teaching environments and materials for STEM education in schools.





**Table 3**

STEM centers established within universities, research institutions, or other organizations

Center	Funded by	Link
STEM Education and Coordination Center	Co-funded by EU and Türkiye	<a href="https://stemegitimmerkezi.com/">https://stemegitimmerkezi.com/</a>
STEM School - Istanbul Aydın University	University funded	<a href="http://stemokulu.com/stem-okulu-hakkinda/">http://stemokulu.com/stem-okulu-hakkinda/</a>
STEM and Science Center	Funded by Erasmus+ Ka2 Project	<a href="https://www.urfastem.gov.tr/">https://www.urfastem.gov.tr/</a>
Diyarbakır STEM Center	Co-funded by Development agency and Ministry of Education	<a href="https://www.diyarbakirstemmerkezi.com/hakkimizda">https://www.diyarbakirstemmerkezi.com/hakkimizda</a>
Kahramanmaraş Stem Center	Funded by Provincial Municipality	<a href="https://kahramanmaraş.bel.tr/stem-merkezi">https://kahramanmaraş.bel.tr/stem-merkezi</a>
Bursa Innovation Center	Co-funded by Provincial Directorate of National Education and Development Agency	<a href="https://www.bursainovasyonmerkezi.com/ortaokul-ogrencileri-icin-stem-atolyesi/">https://www.bursainovasyonmerkezi.com/ortaokul-ogrencileri-icin-stem-atolyesi/</a>
Ülker AYDIN STEM Center	Funded by Provincial Municipality	<a href="https://tarsus.bel.tr/tr/stem-merkezi/">https://tarsus.bel.tr/tr/stem-merkezi/</a>
Turkish Stem Education Association	A researcher initiative	<a href="http://stemtr.org/">http://stemtr.org/</a>
Istanbul STEM Learning Center Project	Funded by Development Agency	<a href="https://i-stemmerkezi.com/?fbclid=PAAaZy4dRuRAi2cgxELKzfWclvg-Um8UMqL_PM0i3zJ0PPBVvNTASpa9g3tz0">https://i-stemmerkezi.com/?fbclid=PAAaZy4dRuRAi2cgxELKzfWclvg-Um8UMqL_PM0i3zJ0PPBVvNTASpa9g3tz0</a>
STEM Lab	University funded	<a href="https://www.izu.edu.tr/akademik/fakulteler/egitim-fakultesi/laboratuvarlar/stem-laboratuvari">https://www.izu.edu.tr/akademik/fakulteler/egitim-fakultesi/laboratuvarlar/stem-laboratuvari</a>
Hacettepe STEM & Maker Lab	University funded	<a href="https://hstem.hacettepe.edu.tr/">https://hstem.hacettepe.edu.tr/</a>
Muğla Sıtkı Koçman University Science Education Research & Application Center	University funded	<a href="https://mubem.mu.edu.tr/tr/mubem-projeler-1739">https://mubem.mu.edu.tr/tr/mubem-projeler-1739</a>
BİLTEM   Center for Science Technology Engineering and Mathematics Education	University funded	<a href="https://biltemm.metu.edu.tr/tr">https://biltemm.metu.edu.tr/tr</a>



Morover, Istanbul Aydın University, a leading institution in the field of STEM education, has established a STEM center to provide top-notch laboratory facilities and exemplary education in STEM for teachers and students. The center aims to bring together individuals and organizations involved in STEM activities in Türkiye and provide support for all STEM initiatives in the country (Akgündüz et al., 2015). According to a report, universities are the ideal institutions to establish STEM centers, with Hacettepe University and Istanbul Aydın University already having done so. However, these efforts are not enough to fully integrate STEM education into formal education. To achieve this, education and engineering faculties should form STEM centers and collaborate with MEB's STEM center. These centers can offer research opportunities to integrate STEM education into the education system, provide up-to-date training, update the curriculum, offer professional development opportunities for teachers, facilitate project partnerships, and organize competitions for teachers and students. A coordinated structure is proposed in the diagram below.

STEM centers have been emphasized as necessary in academic studies and reports (Akgündüz et al., 2015; Uğraş, 2017; Türk, 2019; Uyar, Canpolat, Şan, 2021). Bahçeşehir University established the BAUSTEM STEM Center within their Teacher Professional Development Application and Research Center in 2016 to provide training to increase teachers' STEM application skills. The STEM: Leader Teacher Professional Development Program aims to maintain effective communication and interaction between teachers and academics (see <https://inteach.org/hakkimizda/>). The Middle East Technical University (METU) BİLTEM Education Application and Research Center aims to advance education in science, technology, engineering, and mathematics through studies conducted by a group of researchers consisting of faculty members from different disciplines. Their objectives include providing educational opportunities to schools, teachers, and students in the relevant fields and training teacher candidates at the undergraduate level (see <https://inteach.org/hakkimizda/>). Hacettepe STEM & Maker Lab, established within the body of Hacettepe University in 2009, participates in projects within the scope of European Union Framework Programs to raise individuals not only at the national but also at the international level (see <https://hstem.hacettepe.edu.tr/>). Below is a table displaying the STEM centers and laboratories that



**Table 4**

STEM Centers within universities in Turkey

University	Name of the Center	Year of Foundation
Hacettepe University	Hacettepe Science, Technology, Engineering and Mathematics Education and Applications Laboratory	2009
Yalova University	Science and Technology Application and Research Center	2011
Muğla Sıtkı Koçman University	Science Education Application and Research Center	2013
İstanbul Aydın University	Istanbul Aydın University STEM Laboratory	2015
Bahçeşehir University	Teacher Professional Development Application and Research Center – (BAUSTEM)	2016
Van Yüzüncü Yıl University	Science Technology Engineering and Mathematics Education Application and Research Center	2017
Yıldız Technical University	STEM Labrotary	2017
Aydın Adnan Menderes University	Science, Technology, Engineering and Mathematics Education Application and Research Center	2018
İstanbul Gedik University	Science, Technology, Engineering, Mathematics Application and Research Center	2018
Muş Alparslan University	STEM Education Application and Research Center	2019
İstanbul Zaim University	Faculty of Education STEM laboratory	2018
ODTU (Ortadoğu Technical University)	BİLTEM Science, Technology, Engineering and Mathematics Education Application and Research Center	2017

*Note. Source: Polat, Ö. & Bardak, M. (2019). STEM Approach in Early Childhood in Türkiye. International Journal of Social Science Research, 8(2), 18-41.*

Integrating STEM (science, technology, engineering, and mathematics) practices into science centers and museums can be an effective way to engage visitors with hands-on, interactive exhibits that promote inquiry-based learning. Here are some ways to integrate STEM practices into science centers:



1. Offer interactive exhibits that promote inquiry-based learning: Science museums can create exhibits that encourage visitors to ask questions, make observations, and test hypotheses. For example, a physics exhibit might feature hands-on experiments with pendulums or demonstrate the properties of sound waves using interactive displays.
2. Use technology to enhance exhibits: Science museums can use technology to enhance exhibits and provide visitors with new ways to interact with scientific concepts. Virtual reality, augmented reality, and interactive displays can help visitors visualize complex scientific concepts in new and exciting ways.
3. Offer STEM-related programs and workshops: Science museums can offer programs and workshops that provide visitors with opportunities to learn about STEM concepts through hands-on activities. For example, a robotics workshop might teach visitors how to build and program a robot.
4. Partner with local schools and universities: Science museums can partner with local schools and universities to provide educational programs that complement classroom learning. This can include field trips, science fairs, and science camps.
5. Encourage visitors to participate in citizen science projects: Science museums can encourage visitors to participate in citizen science projects, which allow them to contribute to real scientific research. For example, a museum might host a bird-watching event and ask visitors to record their observations for a research project. Table 5 showcases noteworthy science centers and museums that receive high visitation.

STEM Centers in Türkiye offer both STEM Basic Level and STEM Advanced Level Trainings, and they provide ongoing training for teachers. The activities at the center are coordinated with the STEM activities planned by teachers in schools, and the center monitors students' interest and attitude scales, as well as their academic achievements. Trained teachers are visited periodically, and a science festival is held annually to exhibit student and teacher products. Some STEM centers also provide guidance activities for teachers on integrating STEM into their curriculum, as well as repairing and supporting materials used in STEM education.

STEM education is available at all levels, from kindergarten to university students, and the centers are generally located in city centers with easy transportation access. Free education is provided to students, but due to high demand, some centers can only offer STEM education one day a week per student. STEM Centers offer a variety of services and resources to their visitors. The event implementation



times are flexible and are determined by an appointment system in some centers, while others provide training between 16:00 and 22:00. The physical conditions of some centers are considered sufficient to meet the needs of their visitors. The STEM classes available in these centers cater to a wide range of ages and educational levels, from kindergarten to vocational high school. The classes cover various concepts such as industrial robotics, coding, and scientific inquiry. The centers also provide individual workshops and intelligence games workshops. In addition, the centers offer several STEM workshops for kindergarten, primary, secondary, and high schools. Some centers are equipped with Fischer technical building sets, Lego and Arduino robot sets, science laboratory materials, three-dimensional printers, and computers (Bircan, Köksal & Cımbız, 2019; Uyar, Canpolat & Şan, 2021; Karaduman & İnanç, 2023). Public and Private Universities provide various resources and training programs for teachers, undergraduate students, primary and secondary school students. Istanbul Aydın University is one of the institutions that has established STEM centers and laboratories to contribute to STEM education. The STEM Laboratory at Istanbul Aydın University offers a STEM teacher training program, both face-to-face and online education programs, as well as integrated STEM education for students. Additionally, the university also provides support to institutions that are interested in establishing their own STEM labs. Additionally, Istanbul Aydın University's STEM center also focuses on environmental STEM education and provides STEM education to vocational and technical high schools.



Table 5.

Noteworthy Science Centers and Museums That Receive High Visitation

Center	Funded by	Info	Link
Bursa Science and Technology Center: BTM	Bursa Metropolitan Municipality's vision project	The goal of the Bursa Science and Technology Center is to promote sustainable development, foster a society based on science, and train future scientists, with the aim of accelerating Turkey's progress in the field of science and technology and serving as a model for the entire country.	<a href="http://www.bursabilimmerkezi.org/">http://www.bursabilimmerkezi.org/</a>
Konya Science Center	Konya Metropolitan Municipality	The Konya Science Center, established by the Konya Metropolitan Municipality and supported by TÜBİTAK, is Turkey's first science center. Its goal is to cultivate a passion for science in people aged 7 to 70 and encourage interest in science throughout all levels of society.	<a href="https://www.konyabilimmerkezi.com/">https://www.konyabilimmerkezi.com/</a>
Kayseri Science Center	Kayseri Metropolitan Municipality and TUBİTAK	The goal is to merge theory and practice for young individuals to work, create, succeed, and adapt to current demands.	<a href="https://www.kayseribilimmerkezi.com/">https://www.kayseribilimmerkezi.com/</a>
Space Camp Turkey	Private funded Science Museum	Space Camp Turkey, a space and center, is focused on motivating young people to pursue careers in science, mathematics and technology. In programs related to STEAM (Science-Technology-Engineering-Art-Mathematics) learning approaches; increasing their interest in creative sciences through applied training; Suggestions for establishing dialogue, questioning and critical thinking are aimed to be guiding. A dynamic and fun journey used by space-related operations, both for children and adults; training in communication, teamwork and management. Providing scientific education, Space Camp Turkey, headquartered in Huntsville Alabama, has the American Space Sciences Exhibition Commission License and is a member of the Turkish Camps Association.	<a href="https://www.spacecampturkey.com">https://www.spacecampturkey.com</a>
Eskişehir Science and Experiment Center	Eskişehir Metropolitan Municipality	The Eskişehir Science Experiment Center is created with the aim of educating our upcoming generation. It provides an opportunity for children who are interested in science, eager to learn by experimenting and observing, to utilize various experimental tools and gain new knowledge. Both young and old who share a common curiosity are welcome to visit the center.	<a href="http://www.eskisehirbilimdeneymerkezi.com/default.aspx">http://www.eskisehirbilimdeneymerkezi.com/default.aspx</a>
Istanbul Technical University (ITU) Science Center	Istanbul Technical University	The ITU Science Center aims to provide students of all ages with hands-on experiences in science, technology, and nature's fundamental laws. Its goal is to promote scientific culture in society, making science and technology accessible and popular, and inspiring people of all ages to engage in these fields.	<a href="https://www.bilimmerkezi.itu.edu.tr/hakkinda/itu-bilim-merkezi/">https://www.bilimmerkezi.itu.edu.tr/hakkinda/itu-bilim-merkezi/</a>
Kocaeli Science Center	Kocaeli Metropolitan Municipality-TUBİTAK	The Kocaeli Science Center, a collaboration between Kocaeli Metropolitan Municipality and TUBİTAK, intends to unite science and technology with people of various ages and levels of understanding, while promoting the significance of these fields in society.	<a href="http://www.kocaelibilimmerkezi.com/">http://www.kocaelibilimmerkezi.com/</a>



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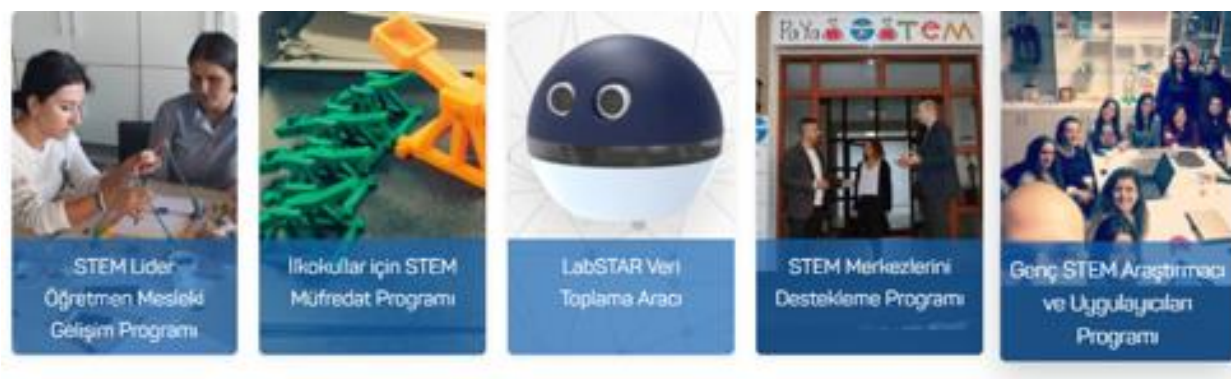


Moreover, BİLTEM: The Science, Technology, Engineering and Mathematics Education Application and Research Center, as located in Middle East Technical University, offers various programs and projects to support STEM education. These initiatives include teacher training workshops, STEM days, as well as national and international projects and studies. The center also conducts interdisciplinary practices and innovation development workshops, such as the Edusteam Project, to promote STEAM studies. Bahçeşehir University's BAUSTEM center offers a range of programs and resources to support STEM education. These include a Young STEM researcher and practitioner program, designed to provide support to STEM centers, as well as several STEM education programs. The center has also published educational books on STEM Theory and Practices, which provide a basic guide for teachers, as well as guides specifically tailored for primary schools (See Figure 6).





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Note. Images are taken from BAUSTEM official website

**Figure 6.** STEM Initiatives and Books Published by BAUSTEM

The Payas Stem Center is a remarkable educational facility located in the Payas district of Hatay province in Türkiye. This center is housed in a two-story building spanning an area of 700 m<sup>2</sup> and is notable for being established outside of metropolitan cities. Among its offerings are classes in Robotic Coding, Mathematical Modeling, Scientific Inquiry, World of Words, and Mind Games sections. Students who attend classes at the Payas Stem Education Center benefit from engaging workshops that utilize a variety





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of educational tools, including Sensors, Electronic Circuits, 3D Printers, Lego Minstorms EV3s, and Mind Games.

In conclusion, the evaluation of academic research, reports, and studies conducted in STEM centers reveals a diverse range of applications, projects, and workshops aimed at promoting STEM education in Türkiye, alongside supportive initiatives for newly established centers. Moreover, valuable educational resources, including books and brochures, are being developed to aid teachers and students in the pursuit of academic excellence. These efforts serve as a testament to the importance of STEM education and the commitment of Turkish institutions to nurturing a thriving culture of scientific inquiry and technological innovation.



## REFERENCES

\*Articles with TR Index Analyzed in This Paper.

4th International STEM Education Conference. STEMpd. Retrieved April 17, 2023, from <https://www.stempd.net/>

Abanoz, T., & Yabas, D. (2022). My world of machines: an integrated STEM education curriculum for early childhood teachers. *European Early Childhood Education Research Journal*.  
<https://doi.org/10.1080/1350293X.2022.2127822>

Acar, D., Ecevit, T. & Büyüksahin, Y. (2020). Fen bilimleri öğretmen adaylarının STEM eğitime yönelik metaforik algıları. *Ahi Evran Üniversitesi Kırşehir Eğitim Fakültesi Dergisi*, 21(3), 1839-1873. \*TR Indexed

Aciksoz, A. , Ozkan, Y. Ö. & Dokme, I. (2020). Adaptation of the STEM Value-Expectancy Assessment Scale to Turkish Culture . *International Journal of Assessment Tools in Education*, 7 (2) , 177-190. <https://doi.org/10.21449/ijate.723408> \*TR Indexed

Adsay, C. , Korkmaz, Ö. , Çakır, R. & Uğur Erdoğan, F. (2020). Ortaokul öğrencilerinin blok temelli kodlama eğitimine dönük öz-yeterlik algı düzeyleri, STEM ve bilgisayarca düşünme beceri düzeyleri. *Eğitim Teknolojisi Kuram ve Uygulama*, 10(2), 469-489. <https://doi.org/10.17943/etku.696224> \*TR Indexed

Akar, H. & Yadigaroglu, M. (2021). Fen, teknoloji, mühendislik ve matematik (FETEMM) temelli etkinliklerin 5. sınıf öğrencilerinin madde ve değişim ünitesindeki kavramları günlük yaşamla ilişkilendirmelerine etkisi. *Erzincan Üniversitesi Eğitim Fakültesi Dergisi*, 23(1), 57-81 . <https://doi.org/10.17556/erziefd.656886> \*TR Indexed

Akçapınar, G. & Coşgun, E. (2019). Öğrencilerin STEM eğitimi tercihlerinin veri madenciliği yaklaşımı ile tahmin edilmesi. *Eğitim Teknolojisi Kuram ve Uygulama*, 9(1) , 73-88 . <https://doi.org/10.17943/etku.429785> \*TR Indexed

Akgün, K. & Türel, Y. K. (2021). Bilgisayar ve öğretim teknolojileri eğitimi bölümü öğrencilerinin stem yaklaşımına yönelik farkındalıklarının belirlenmesi. *Eğitim Teknolojisi Kuram ve Uygulama*, 11(1), 116-128.  
<https://dergipark.org.tr/tr/pub/etku/issue/60079/771011> \*TR Indexed

Akgündüz, D., Aydeniz, M., Çakmakçı, G., Çavaş, B., Corlu, M. S., Öner, T., & Özdemir, S. (2015). A report on STEM Education in Türkiye: A provisional agenda or a necessity? [Technical Report]. İstanbul, Türkiye: Aydın Üniversitesi. Retrieved from <http://www.aydin.edu.tr/belgeler/IAU-STEM-Egitimi-Turkiye-Raporu-2015.pdf>

Akkaş Baysal, E. , Ocak, G. & Ocak, İ. (2020). Kodlama ve arduino eğitimleri ile ilgili lise öğrencilerinin görüşleri. *Elektronik Sosyal Bilimler Dergisi*, 19(74), 777-796. <https://doi.org/10.17755/esosder.625496> \*TR Indexed

Akpınar, B. C., & Akgunduz, D. (2022). The Effect of STEM Applications in Preschool on Students' Carrier Goals and Perceptions of Engineering. *INTERNATIONAL JOURNAL OF EARLY CHILDHOOD*, 54(3), 361–381.  
<https://doi.org/10.1007/s13158-022-00330-1>

Alan, B., Zengin, F. K., & Kecici, G. (2019). Using STEM applications for supporting integrated teaching knowledge of pre-service science teachers. *Journal Of Baltic Science Education*, 18(2), 158–170.  
<https://doi.org/10.33225/jbse/19.18.158>



- Alan, B., Zengin, F. K., & Kececi, G. (2021). Effects of Science, Technology, Engineering, and Mathematics Education Using Algodoo to Prospective Science Teachers' Scientific Process and Education Orientation Skills. *Journal of Education*, 0(0). <https://doi.org/10.1177/00220574211044542>
- Altan, E. B., & Ucuncuoglu, I. (2019). Examining the Development of Pre-Service Science Teachers' STEM-Focused Lesson Planning Skills. *Eurasian Journal Of Educational Research*, 83, 103–124. <https://doi.org/10.14689/ejer.2019.83.5>
- Altun, E. & Apaydın, Z. (2022). Sınıf öğretmenlerinin STEM yaklaşımına yönelik farkındalık düzeyleri ve tutumları. *Van Yüzüncü Yıl Üniversitesi Eğitim Fakültesi Dergisi*, 19(2), 527-545. <https://doi.org/10.33711/yyuefd.1108245> \*TR Indexed
- Arslanhan, H. & İnaltekin, T. (2020). Tasarım Temelli Öğrenme Uygulamalarının Fen Bilimleri Öğretmen Adaylarının STEM Anlayışlarını Geliştirmeye Etkisi . *Van Yüzüncü Yıl Üniversitesi Eğitim Fakültesi Dergisi* , 17 (1) , 231-265 . <https://doi.org/10.33711/yyuefd.691585> \*TR Indexed
- Ata Aktürk A., Demircan, H.Ö.; Şenyurt, E. & Çetin, M. (2017). Turkish early childhood education curriculum from the perspective of STEM education: A document analysis. *Journal of Turkish Science Education*, 14(4), 16–34.
- Ata-Akturk, A. (2023). ``Teacher, I know how to do it{'}``: An engineering design-based STEM activity on the concepts of forces and floating/sinking for young problem solvers. *Science Activities-Projects And Curriculum Ideas In Stem Classrooms*, 60(1), 12–24. <https://doi.org/10.1080/00368121.2022.2128709>
- Ata-Akturk, A., & Demircan, H. O. (2021). Supporting Preschool Children's STEM Learning with Parent-Involved Early Engineering Education. *Early Childhood Education Journal*, 49(4), 607–621. <https://doi.org/10.1007/s10643-020-01100-1>
- Ata-Akturk, A., & Demircan, H. O. (2022). Engineers and engineering through the eyes of preschoolers: a phenomenographic study of children's drawings. *European Early Childhood Education Research Journal*, 30(4), 495–514. <https://doi.org/10.1080/1350293X.2021.1974067>
- Ata, A. O. & Arslan, H. Ö. (2021). Fen bilimleri öğretmenlerinin STEM eğitimi yaklaşımına yönelik hazırbulunuşluk durumlarının incelenmesi. *Van Yüzüncü Yıl Üniversitesi Eğitim Fakültesi Dergisi*, 18(2), 405-436. <https://doi.org/10.33711/yyuefd.1029055> \*TR Indexed
- Ata, R., & Cevik, M. (2020). Understanding predictor effects of computational thinking skills and media and technology use and attitudes of pre-service teachers for STEM awareness. *Kedi Journal Of Educational Policy*, 17(1), 99–121.
- Ayaz, M., Gülen, S. & Gök, B. (2020). STEM etkinliklerinin uygulanması sürecinde elektronik portfolyo kullanımının sekizinci sınıf öğrencilerinin fen bilimleri dersi akademik başarısına ve STEM Tutumuna etkisinin incelenmesi. *Van Yüzüncü Yıl Üniversitesi Eğitim Fakültesi Dergisi*, 17 (1), 1153-1179. <https://doi.org/10.33711/yyuefd.801394> \*TR Indexed
- Aydeniz, M. (2017). Eğitim sistemimiz ve 21. yüzyıl hayalimiz: 2045 hedeflerine İlerlerken, Türkiye için STEM odaklı ekonomik bir yol haritası. University of Tennessee, Knoxville.
- Aydın, E. & Karslı, F. (2019). Yedinci sınıf öğrencilerinin STEM etkinlikleri hakkındaki görüşleri: karışımların ayrıştırılması örneği. *OndokuzMayısUniversityJournal of EducationFaculty* , 38(1), 35-52. <https://dergipark.org.tr/tr/pub/omuefd/issue/46119/439843> \*TR Indexed



- Aydin, S. , Öztay, E. S. & Ekiz, B. (2021). Examination of pre-service chemistry teachers' STEM conceptions through an integrated STEM course. *Turkish Journal of Education*, 10(4), 251-273.  
<https://doi.org/10.19128/turje.894588> \*TR Indexed
- Aydin-Gunbatar, S., Ekiz-Kiran, B., & Oztay, E. S. (2020). Pre-service chemistry teachers' pedagogical content knowledge for integrated STEM development with LESMeR model. *Chemistry Education Research And Practice*, 21(4), 1063–1082. <https://doi.org/10.1039/d0rp00074d>
- Aydin-Gunbatar, S., Oztay, E. S., & Ekiz-Kiran, B. (2021). Examination of pre-service chemistry teachers' STEM conceptions through an integrated STEM course. *Turkish Journal Of Education*, 10(4), 251–273.  
<https://doi.org/10.19128/turje.894588>
- Aydin-Gunbatar, S., Tarkin-Celikkiran, A., Kutucu, E. S., & Ekiz-Kiran, B. (2018). The influence of a design-based elective STEM course on pre-service chemistry teachers' content knowledge, STEM conceptions, and engineering views. *Chemistry Education Research And Practice*, 19(3), 954–972.  
<https://doi.org/10.1039/c8rp00128f>
- Aydin, G. (2020). Prerequisites for Elementary School Teachers before Practicing STEM Education with Students: A Case Study. *Eurasian Journal Of Educational Research*, 88, 1–39. <https://doi.org/10.14689/ejer.2020.88.1>
- Aydogan, B., & Cakiroglu, J. (2022). The Effects of Engineering Design-Based Instruction On 7th Grade Students' Nature of Engineering Views. *Journal Of Science Education And Technology*, 31(1), 68–80.  
<https://doi.org/10.1007/s10956-021-09931-2>
- Aydogdu, B., Kasapoglu, K., Duban, N., Ay, T. S., & Ozdinc, F. (2020). Examining change in perceptions of science teachers about e-stem. *Journal Of Baltic Science Education*, 19(5), 696–717.  
<https://doi.org/10.33225/jbse/20.19.696>
- Aykan, A., & Yildirim, B. (2022). The Integration of a Lesson Study Model into Distance STEM Education during the COVID-19 Pandemic: Teachers' Views and Practice. *Technology Knowledge And Learning*, 27(2), 609–637.  
<https://doi.org/10.1007/s10758-021-09564-9>
- Azgin, A. & Şenler, B. (2019). STEM in primary school: Students' career interest and attitudes. *Journal of Computer and Education Research*, 7(13), 2148-2896. \*TR Indexed
- Bahşi, A. & Açıkgül Fırat, E. (2020). STEM etkinliklerinin 8. sınıf öğrencilerinin bilimsel süreç becerilerine, bilimsel epistemolojik inançlarına ve fen başarılarına etkisinin incelenmesi . *Ondokuz Mayıs University Journal of Education Faculty*, 39 (1), 1-22 . Retrieved from <https://dergipark.org.tr/tr/pub/omuefd/issue/53755/616509>
- Balcin, M. D., & Ergun, A. (2019). Aeronautical and Space Engineers from the Eyes of Sixth Grade Students. *Pamukkale University Journal Of Education*, 45, 1–21. <https://doi.org/10.9779/PUJE.2018.219>
- BapoğluDümeni, S. , Muş, E. & Demir, E. (2021). Analysis of Case Problems by STEM Activities in Children's Stories and Their Effect on Problem-Solving Skills. *Bartın University Journal of Faculty of Education*, 10(2), 378-389. \*TR Indexed
- Baran, E., Bilici, S. C., Mesutoglu, C., & Ocak, C. (2019). The impact of an out-of-school STEM education program on students' attitudes toward STEM and STEM careers. *School Science And Mathematics*, 119(4), 223–235.  
<https://doi.org/10.1111/ssm.12330>



- Barron, B., & Darling-Hammond, L. (2008). Teaching for meaningful learning: A review of research on inquiry-based and cooperative learning. *Powerful Learning: What We Know About Teaching for Understanding*, 11-70.
- Basaran, M., & Erol, M. (2023). Recognizing aesthetics in nature with STEM and STEAM education. *Research In Science & Technological Education*, 41(1), 326–342. <https://doi.org/10.1080/02635143.2021.1908248>
- Bati, K., Yetisir, M. I., Caliskan, I., Gunes, G., & Sacan, E. G. (2018). Teaching the concept of time: A steam-based program on computational thinking in science education. *Cogent Education*, 5(1). <https://doi.org/10.1080/2331186X.2018.1507306>
- Beane, J. A. (1995). Curriculum integration and the disciplines of knowledge. *The Phi Delta Kappan*, 76(8), 616-622.
- BİLTEM Center for Science Technology Engineering and Mathematics Education. Retrieved April 17, 2023, from <https://biltemm.metu.edu.tr/tr>
- Bircan, M. A., & Calisici, H. (2022). The Effects of STEM Education Activities on Fourth Grade Students' Attitudes to Stem, 21st-Century Skills and Mathematics Success. *Egitim Ve Bilim-Education And Science*, 47(211), 87–119. <https://doi.org/10.15390/EB.2022.10710>
- Bircan, M. A., Köksal, Ç., & Cimbiz, A. T. (2019). Türkiye'deki STEM merkezlerinin incelenmesi ve STEM merkezi model önerisi. *Kastamonu Eğitim Dergisi*, 27(3), 1033-1045.
- Bolatlı, Z. & Korucu, A. T. (2018). Secondary school students' feedback on course processing and collaborative learning with web 2.0 tools-supported STEM activities. *Bartın University Journal of Faculty of Education*, 7(2), 456-478. \*TR Indexed
- Bozan, M. A. & Anagün, S. Ş. (2019). STEM focused professional development process of elementary school teachers: An action research. *Anadolu Journal of Educational Sciences International*, 9(1), 279-313. \*TR Indexed
- Bozan, S. & Kaya-capocci, S. (2022). Güçlü ve zayıf yönlerimi nasıl fark ederim öğretmen adaylarının yansıtıcı günlüklerden faydalanarak girişimci STEM ders planları geliştirmesi. *Van Yüzüncü Yıl Üniversitesi Eğitim Fakültesi Dergisi*, 19 (3), 760-779. <https://doi.org/10.33711/yyuefd.1109425> \*TR Indexed
- Buyukdede, M., & Tanel, R. (2019). Effect of the stem activities related to work-energy topics on academic achievement and prospective teachers' opinions on stem activities. *Journal Of Baltic Science Education*, 18(4), 507–518. <https://doi.org/10.33225/jbse/19.18.507>
- Cakir, N. A., Cakir, M. P., & Lee, F. J. (2021). We game on skyscrapers: the effects of an equity-informed game design workshop on students' computational thinking skills and perceptions of computer science. *ETR&D Educational Technology Research And Development*, 69(5), 2683–2703. <https://doi.org/10.1007/s11423-021-10031-6>
- Cakir, N. K., & Guven, G. (2019). Arduino-Assisted robotic and coding applications in science teaching: Pulsimeter activity in compliance with the 5E learning model. *Science Activities-Projects And Curriculum Ideas In Stem Classrooms*, 56(2), 42–51. <https://doi.org/10.1080/00368121.2019.1675574>
- Cakir, R., Korkmaz, O., Idil, O., & Erdogmus, F. U. (2021). The effect of robotic coding education on preschoolers' problem solving and creative thinking skills. *Thinking Skills And Creativity*, 40. <https://doi.org/10.1016/j.tsc.2021.100812>





- Cakir, Z., & Yalcin, S. A. (2022). The Effect of the Montessori Approach-based STEM Activities on the Pre-school Pre-service Teachers' Lifelong Learning. *Pamukkale University Journal Of Education*, 56, 66+. <https://doi.org/10.9779/pauefd.1022966>
- Canbazoglu Bilici, S., Kupeli, M. A., & Guzey, S. S. (2021). Inspired by nature: an engineering design-based biomimicry activity. *Science Activities-Projects And Curriculum Ideas In Stem Classrooms*, 58(2), 77–88. <https://doi.org/10.1080/00368121.2021.1918049>
- Celik, S. A. (2022). An Investigation on the Effect of STEM Practices on Sixth-Grade Students' Problem-Solving Skills, Critical Thinking, and Attitudes Toward STEM. *Pamukkale University Journal of Education*, 56, 287+. <https://doi.org/10.9779/pauefd.1054678>
- Cetin, M., Demircan, H. O., Senyurt, E., & Akturk, A. A. (2020). An Analysis of Young Children's Preferences on STEM Activities in terms of Gender. *Journal of Education And Future-Egitim ve Gelecek Dergisi*, 18, 1–15. <https://doi.org/10.30786/jef.650246>
- Cevik, M. (2018). Impacts of the Project Based (PBL) Science, Technology, Engineering and Mathematics (STEM) Education on Academic Achievement and Career Interests of Vocational High School Students. *Pegem Egitim Ve Ogretim Dergisi*, 8(2), 281–305. <https://doi.org/10.14527/pegegog.2018.012>
- Ceylan, Ö. & Karahan, E. (2021). STEM odaklı matematik uygulamalarının 11. sınıf öğrencilerinin matematik tutum ve bilgileri üzerine etkisi. *Anadolu Journal of Educational Sciences International*, 11(2), 660-683. \*TR Indexed
- Ciftci, A., & Topcu, M. S. (2022). Improving early childhood pre-service teachers' computational thinking teaching self-efficacy beliefs in a STEM course. *Research In Science & Technological Education*. <https://doi.org/10.1080/02635143.2022.2036117>
- Ciftci, A., Topcu, M. S., & Foulk, J. A. (2022). Pre-service early childhood teachers' views on STEM education and their STEM teaching practices. *Research In Science & Technological Education*, 40(2), 207–233. <https://doi.org/10.1080/02635143.2020.1784125>
- Coban, E., Korkmaz, O., Cakir, R., & Erdogmus, F. U. (2020). Attitudes of IT teacher candidates towards computer programming and their self-efficacy and opinions regarding to block-based programming. *Education And Information Technologies*, 25(5), 4097–4114. <https://doi.org/10.1007/s10639-020-10164-w>
- Crippen, K. J., & Archambault, L. (2012). Scaffolded Inquiry-Based Instruction with Technology: A Signature Pedagogy for STEM Education. *Computers in the Schools*, 29(1–2), 157–173. <https://doi.org/10.1080/07380569.2012.658733>
- Czerniak, C. M., Weber, W. B., Sandmann, A., ve Ahern, J. (1999). A literature review of science and mathematics integration. *School Science and Mathematics*, 99(8), 421-430.
- Çakır, Z. & Altun, S. (2021) Montessori yaklaşım temelli STEM etkinliklerinin okul öncesi öğretmen adaylarının problem çözme becerilerine etkisi. *Kuramsal Eğitim Bilim Dergisi*, 14(2), 93-119. \*TR Indexed
- Çevik, M. & Abdioğlu, C. (2018) Bir bilim kampının 8. sınıf öğrencilerinin STEM başarılarına, fen motivasyonlarına ve üstbilişsel farkındalıklarına etkisinin incelenmesi. *İnsan ve Toplum Bilimleri Araştırma Dergisi*, 7(5), 304-327 \*TR Indexed



- Çınar, S. & Terzi, S. Y. (2021). STEM eğitimi almış öğretmenlerin STEM öğretimi hakkındaki görüşleri. *Van Yüzüncü Yıl Üniversitesi Eğitim Fakültesi Dergisi*, 18(2), 213-245. <https://doi.org/10.33711/yyuefd.1028596> \*TR Indexed
- Çil, E. & Özlen, S. (2019). Beşinci sınıf öğrencilerinin mühendis ve mühendislik algılarının incelenmesi. *Bolu Abant İzzet Baysal Üniversitesi Eğitim Fakültesi Dergisi*, 19(4), 1272-1287. \*TR Indexed
- Çolak, E. & Buldur, A. (2022). Okul öncesi öğretmenlerinin STEM farkındalıklarının bazı demografik değişkenler açısından incelenmesi. *e-Kafkas Journal of Educational Research*, 9 (2), 603-620. <https://doi.org/10.30900/kafkasegt.1016235> \*TR Indexed
- Çolakoğlu, M. H., & Gökben, A. G. (2017). Türkiye’de eğitim fakültelerinde FeTeMM (STEM) çalışmaları. *İnformel Ortamlarda Araştırmalar Dergisi*, 2(2), 46-69.
- Dedetürk, A., Kirmuzigul, A. S., & Kaya, H. (2021). The effects of stem activities on 6th grade students’ conceptual development of sound. *Journal Of Baltic Science Education*, 20(1), 21–37. <https://doi.org/10.33225/jbse/21.20.21>
- Delen, I., & Sen, S. (2023). Effect of design-based learning on achievement in K-12 education: A meta-analysis. *Journal Of Research In Science Teaching*, 60(2), 330–356. <https://doi.org/10.1002/tea.21800>
- Delen, I., & Uzun, S. (2018). Evaluating STEM Based Learning Environments Created by Mathematics Pre-Service Teachers. *Hacettepe University Journal Of Education*, 33(3), 617–630. <https://doi.org/10.16986/HUJE.2018037019>
- Demircan, H. O. (2022). “How am I supposed to do this on my own?{’}”: A case study on perspectives of preschool teachers regarding integrative STEM practices. *Journal of Early Childhood Research*, 20(1), 93–112. <https://doi.org/10.1177/1476718X211052749>
- Donmez, I. (2021). Impact of Out-of-School STEM Activities on STEM Career Choices of Female Students. *Eurasian Journal Of Educational Research*, 91, 172–202. <https://doi.org/10.14689/ejer.2021.91.9>
- Dönmez, İ. (2020). STEM motivasyon ölçeğinin Türkçeye uyarlanması: Geçerlik ve güvenilirlik çalışması. *Van Yüzüncü Yıl Üniversitesi Eğitim Fakültesi Dergisi*, 17(1), 486-510. <https://doi.org/10.33711/yyuefd.693825> \*TR Indexed
- Durak, H. Y., Uslu, N. A., Bilici, S. C., & Guler, B. (2022). Examining the predictors of TPACK for integrated STEM: Science teaching self-efficacy, computational thinking, and design thinking. *Education And Information Technologies*. <https://doi.org/10.1007/s10639-022-11505-7>
- Ergun, A., & Balcin, M. D. (2019). The Perception of Engineers by Middle School Students through Drawings. *Eurasian Journal Of Educational Research*, 83, 1–28. <https://doi.org/10.14689/ejer.2019.83.1>
- Ergun, A., & Kiyici, G. (2019). The effect of design based science education applications of science teacher candidates on their perceptions of engineering education and engineer. *Pegem Eğitim Ve Öğretim Dergisi*, 9(4), 1031–1061. <https://doi.org/10.14527/pegegog.2019.033>
- Erkol, M., Artun, H., Temur, A. & Okur, M. (2022). The effect of 3E, 5E and STEM supported learning environment on sustainable development. *Journal of Computer and Education Research*, 10(19), 2148-2896. \*TR Indexed
- Ertem Akbaş, E., Cancan, M. & Balcı, F. (2019). Ortaokul öğrencilerinin FeTeMM (Fen-Teknoloji-Mühendislik-Matematik) alanlarına yönelik ilgilerinin çeşitli değişkenlere göre incelenmesi. *Van Yüzüncü Yıl Üniversitesi*





*Eğitim Fakültesi Dergisi*, 16 (1), 1370-1401. Retrieved from  
<https://dergipark.org.tr/tr/pub/yyuefd/issue/50700/661086>

Gencer, A. S., & Dogan, H. (2020). The Assessment of the Fifth-Grade Students Science Critical Thinking Skills through Design-Based STEM Education. *International Journal Of Assessment Tools In Education*, 7(4), 690–714. <https://doi.org/10.21449/ijate.744640>

Gencer, A. S., Dogan, H., & Bilen, K. (2020). Developing biomimicry STEM activity by querying the relationship between structure and function in organisms. *Turkish Journal Of Education*, 9(1), 64–105. <https://doi.org/10.19128/turje.643785>

Gok, T. (2021). The determination of high school students' attitudes towards stem. *Mier-Journal of Educational Studies Trends and Practices*, 11(1), 137–159. <https://doi.org/10.52634/mier/2021/v11/i1/1755>

Gul, K. S., & Ates, H. (2022). An examination of the effect of technology-based STEM education training in the framework of technology acceptance model. *Education And Information Technologies*. <https://doi.org/10.1007/s10639-022-11539-x>

Guleryuz, H., & Dilber, R. (2022). Robotic coding and 3D printer with STEM activities; the effect of science teacher candidates on STEM awareness and STEM self-efficacy. *Education And Information Technologies*. <https://doi.org/10.1007/s10639-022-11257-4>

Gunbatar, M. S., & Bakirci, H. (2019). STEM teaching intention and computational thinking skills of pre-service teachers. *EDUCATION AND INFORMATION TECHNOLOGIES*, 24(2), 1615–1629. <https://doi.org/10.1007/s10639-018-9849-5>

Gunbatar, S. A., Oztay, E. S., & Kiran, B. E. (2022). Supporting pre-service teachers' integration of engineering into STEM lessons throughout engineering-infused training. *RESEARCH IN SCIENCE \& TECHNOLOGICAL EDUCATION*. <https://doi.org/10.1080/02635143.2022.2121691>

Guyen, G., Cakir, N. K., Sulun, Y., Cetin, G., & Guven, E. (2022). Arduino-assisted robotics coding applications integrated into the 5E learning model in science teaching. *Journal Of Research On Technology In Education*, 54(1), 108–126. <https://doi.org/10.1080/15391523.2020.1812136>

Guvencilir, M., & Olcay, M. (2019). Engineering Design Process in Education. *9th International Conference The Future Of Education*, 496–501.

Gülen, S. & Yaman, S. (2018). Fen bilimleri dersinde argümantasyon süreci ve STEM disiplinlerinin kullanımı; odak grup görüşmesi. *Van Yüzüncü Yıl Üniversitesi Eğitim Fakültesi Dergisi*, 15(1), 1184-1211. Retrieved from <https://dergipark.org.tr/tr/pub/yyuefd/issue/40566/496247>

Gülhan, F. & Şahin, F. (2018). Fen bilimleri dersine STEM entegrasyonu etkinliklerinin 5. sınıf öğrencilerinin bilimsel yaratıcılıklarına etkisi. *Sakarya University Journal of Education*, 8(4), 40-59. <https://doi.org/10.19126/suje.423105> \*TR Indexed

Hacettepe STEM & Maker Lab. Retrieved April 17, 2023, from <https://hstem.hacettepe.edu.tr>

Hacioglu, Y., & Donmez Usta, N. (2020). Digital game design-based STEM activity: Biodiversity example. *Science Activities-Projects And Curriculum Ideas In Stem Classrooms*, 57(1), 1–15. <https://doi.org/10.1080/00368121.2020.1764468>



- Higde, E., & Aktamis, H. (2022). The effects of STEM activities on students' STEM career interests, motivation, science process skills, science achievement and views. *Thinking Skills And Creativity*, 43. <https://doi.org/10.1016/j.tsc.2022.101000>
- Hiğde, E., Keleş, F. & Aktamış, H. (2020). STEM alanlarına ve öğretimine yönelik tutumları inceleyen model çalışması. *Bolu Abant İzzet Baysal Üniversitesi Eğitim Fakültesi Dergisi*, 20(2), 1145-1160. \*TR Indexed
- Ince, E. Y., & Koc, M. (2021). The consequences of robotics programming education on computational thinking skills: An intervention of the Young Engineer's Workshop (YEW). *Computer Applications In Engineering Education*, 29(1), 191–208. <https://doi.org/10.1002/cae.22321>
- Johnston, A. C., Akarsu, M., Moore, T. J., & Guzey, S. S. (2019). Engineering as the integrator: A case study of one middle school science teacher's talk. *Journal Of Engineering Education*, 108(3), 418–440. <https://doi.org/10.1002/jee.20286>
- Kacan, S. D., & Sahin, F. (2018). Analysis of Science Teacher Candidates' Relation between Scientific Creative Thinking Skills, Creative Problem Solving and Project Development Skills. In E. Masal, I. Onder, H. Caliskan, & S. Besoluk (Eds.), *Erpa International Congresses On Education 2018 (Erpa 2018)* (Vol. 48). <https://doi.org/10.1051/shsconf/20184801059>
- Kalkınma Bakanlığı[KB]. (2013). Onuncu kalkınma planı (2014-2018).
- Kalyenci, D., Metin, S., & Basaran, M. (2022). Test for assessing coding skills in early childhood. *Education And Information Technologies*, 27(4), 4685–4708. <https://doi.org/10.1007/s10639-021-10803-w>
- Karabolat B., Atıcı T. ve Taflı, T. (2021). Biyoloji Dersi Öğretim Programında ve Ders Kitaplarında Yer Alan Kazanımların ve Etkinliklerin STEM Yaklaşımına Göre İncelenmesi. *Mehmet Akif Ersoy Eğitim Fakültesi Dergisi*, 58, 645 – 670.
- Karademir Coşkun, T., Alakurt, T. & Yılmaz, B. (2020). Bilişim teknolojileri öğretmenlerinin perspektifinden STEM eğitimi. *Abant İzzet Baysal Üniversitesi Eğitim Fakültesi Dergisi*, 20 (2), 820-836. \*TR Indexed
- Karaduman, B ve İnanç, E (2023). Herkes için STEM: Bir STEM eğitim merkezinde görev yapan eğitim personelinin STEM eğitimine ilişkin görüşleri. *Trakya Eğitim Dergisi*, 13(1), 209-225.
- Karamustafaoglu, O., & Pektas, H. M. (2022). Developing students' creative problem solving skills with inquiry-based STEM activity in an out-of-school learning environment. *Education And Information Technologies*. <https://doi.org/10.1007/s10639-022-11496-5>
- Kartal, B., & Tasdemir, A. (2021). Pre-Service Teachers' Attitudes towards STEM: Differences Based on Multiple Variables and the Relationship with Academic Achievement. *International Journal Of Technology In Education*, 4(2, SI), 200–228. <https://doi.org/10.46328/ijte.58>
- Kınık Topalsan, A. (2018). Sınıf Öğretmenliği Öğretmen Adaylarının Geliştirdikleri Mühendislik Tasarım Temelli Fen Öğretim Etkinliklerinin Değerlendirilmesi . *Van Yüzüncü Yıl Üniversitesi Eğitim Fakültesi Dergisi* , 15 (1) , 186-219 . Retrieved from <https://dergipark.org.tr/tr/pub/yyuefd/issue/40566/493847> \*TR Indexed
- Kızılay, E., Yamak, H. & Kavak, N. (2019). MotivationscaleforSTEM fields. *Journal of Computer and Education Research*, 7(14), 2148-2896. \*TR Indexed



- Kirkic, K. A., & Uludag, F. (2021). STEM attitudes of students as predictor of secondary school technology and design course achievement. *Problems Of Education In The 21st Century*, 79(4), 585–596.  
<https://doi.org/10.33225/pec/21.79.585>
- Korkmaz, Ö. , Acar, B. , Çakır, R. , Uğur Erdoğan, F. & Çakır, E. (2019). Eğitsel robot setleri ile fen ve teknoloji dersi basit makineler konusunun ortaokul 7. sınıf öğrencilerinin stem beceri düzeylerine ve derse dönük tutumlarına etkisi. *Eğitim Teknolojisi Kuram ve Uygulama*, 9(2) , 372-391 . DOI: 10.17943/etku.518215 \*TR Indexed
- Koyunlu Ünlü, Z. & Dere, Z. (2018). Okul öncesi öğretmen adaylarının hazırladıkları FETEMM etkinliklerinin değerlendirilmesi. *Ahi Evran Üniversitesi Kırşehir Eğitim Fakültesi Dergisi*, 19 (2), 1502-1512. \*TR Indexed
- Koyunlu Ünlü, Z. & Dere, Z. (2019). Okul öncesi öğretmen adaylarının FeTeMM farkındalıklarının değerlendirilmesi. *Erzincan Üniversitesi Eğitim Fakültesi Dergisi*, 21(1) , 44-55 .<https://doi.org/10.17556/erziefd.481586> \*TR Indexed
- Kumas, A. (2021). Evaluation of logger pro innovative technology supported applications in the scope of stem. *Problems Of Education In The 21st Century*, 79(5), 751–766. <https://doi.org/10.33225/pec/21.79.751>
- Kutlu, E. & Bakırcı, H. (2022) Examination of Eighth Grade Students' views on STEM Supported Science Teaching: Simple Machines Unit. *Journal of Computer and Education Research*, 10(20), 2148-2896 \*TR Indexed
- Kuvac, M., & Koc, I. (2022). Enhancing preservice science teachers' perceptions of engineer and engineering through STEM education: a focus on drawings as evidence. *Research In Science & Technological Education*.  
<https://doi.org/10.1080/02635143.2022.2052038>
- Malcok, B. A., & Ceylan, R. (2022). The effects of STEM activities on the problem-solving skills of 6-year-old preschool children. *European Early Childhood Education Research Journal*, 30(3), 423–436.  
<https://doi.org/10.1080/1350293X.2021.1965639>
- MEB (2016). Milli Eğitim Bakanlığı, Yenilik ve Eğitim Teknolojileri Genel Müdürlüğü. Erişim adresi:  
[http://yegitek.meb.gov.tr/meb\\_iys\\_dosyalar/2016\\_978-975-11-3989-4\\_STEM-fentechnoloji-muhendislik-matematik-egitim-raporu.pdf](http://yegitek.meb.gov.tr/meb_iys_dosyalar/2016_978-975-11-3989-4_STEM-fentechnoloji-muhendislik-matematik-egitim-raporu.pdf)
- MEB. (2015). Millî Eğitim Bakanlığı 2015–2019 Stratejik Planı.
- MEB. (2016). Milli Eğitim Bakanlığı STEM Eğitimi Raporu.
- MEB. (2018). Milli Eğitim Bakanlığı 2023 Eğitim Vizyonu Belgesi.
- MEB. (2019). Milli Eğitim Bakanlığı PISA 2018 Türkiye Ön Raporu.
- Meral, M. & Altun Yalçın, S. (2022). The effect of entrepreneurship-based STEM education on secondary school students' self-regulation skills. *Sakarya University Journal of Education* , 12(1), 150-162.  
<https://doi.org/10.19126/suje.1023729> \*TR Indexed
- Muğla Sıtkı Koçman University Science Education Research & Application Center. Retrieved April 17, 2023, from <https://mubem.mu.edu.tr/tr>
- Mumcu, F., Uslu, N. A., & Yildiz, B. (2023). Teacher development in integrated STEM education: Design of lesson plans through the lens of computational thinking. *Education And Information Technologies*, 28(3), 3443–3474. <https://doi.org/10.1007/s10639-022-11342-8>



- Nağaç, M. & Kalaycı, S. (2021). The effect of STEM activities on students' academic achievement and problem solving skills: Matter and heat unit. *e-Kafkas Journal of Educational Research*, 8(3), 480-498. <https://doi.org/10.30900/kafkasegt.964063>
- Ozcakir Sumen, O., & Calisici, H. (2022). The effects of STEM activities applied in mathematics courses for elementary pre-service teachers in Türkiye. *International Journal Of Mathematical Education In Science And Technology*, 53(12), 3352–3376. <https://doi.org/10.1080/0020739X.2021.1944679>
- Ozcan, H., & Koca, E. (2019). The Impact of Teaching the Subject ``Pressure{''} with STEM Approach on the Academic Achievements of the Secondary School 7th Grade Students and Their Attitudes Towards STEM. *Egitim Ve Bilim-Education And Science*, 44(198), 201–227. <https://doi.org/10.15390/EB.2019.7902>
- Ozdinc, F., Kayab, G., Mumcu, F., & Yildiz, B. (2022). Integration of computational thinking into STEM activities: an example of an interdisciplinary unplugged programming activity. *Science Activities-Projects And Curriculum Ideas In Stem Classrooms*, 59(3), 151–159. <https://doi.org/10.1080/00368121.2022.2071817>
- Ozkan, G., & Topsakal, U. U. (2021). Exploring the effectiveness of STEAM design processes on middle school students' creativity. *International Journal Of Technology And Design Education*, 31(1), 95–116. <https://doi.org/10.1007/s10798-019-09547-z>
- Ozkan, G., & Umdü Topsakal, U. (2021). Investigating the effectiveness of STEAM education on students' conceptual understanding of force and energy topics. *Research In Science & Technological Education*, 39(4), 441–460. <https://doi.org/10.1080/02635143.2020.1769586>
- Ozkul, H., & Ozden, M. (2020). Investigation of the Effects of Engineering-Oriented STEM Integration Activities on Scientific Process Skills and STEM Career Interests: A Mixed Methods Study. *Egitim Ve Bilim-Education And Science*, 45(204), 41–63. <https://doi.org/10.15390/EB.2020.8870>
- Özcan, H. & Koştur, H. İ. (2018). Fen bilimleri dersi öğretmenlerinin STEM eğitimine yönelik görüşleri. *Sakarya University Journal of Education*, 8(4), 364-373. <https://doi.org/10.19126/suje.466841> \*TR Indexed
- Özçakır Sümen, Ö. & Çalışıcı, H. (2019). STEM proje tabanlı öğrenme ortamında sınıföğretmeni adaylarının geliştirdikleri matematik projelerinin incelenmesi. *OndokuzMayısUniversityJournal of EducationFaculty*, 38 (1), 238-252. <https://dergipark.org.tr/tr/pub/omuefd/issue/46119/521012> \*TR Indexed
- Özkızılcık, M. & Betül Cebesoy, Ü. (2020). Tasarım temelli FeTeMM etkinliklerinin fen bilgisiöğretmen adaylarının problem çözme becerilerine ve FeTeMM öğretimi yönelimlerineetkisinin incelenmesi. *Uludağ Üniversitesi Eğitim Fakültesi Dergisi*, 33 (1), 177-204<https://doi.org/10.19171/uefad.588222> \*TR Indexed
- Öztürk, F. & Özdemir, D. (2020). The effect of STEM education approach in scienceteaching: Photosynthesis experiment example. *Journal of Computer and Education Research*, 8(16), 2148-2896 \*TR Indexed
- Pekmez, E., Yılmaz, H., Alaçam Akşit, A. C. & Güler, F. (2018). İlköğretim öğrencilerinin fen-teknoloji-tasarım süreci ile ilgili becerilerinin geliştirilmesi üzerine bir eğitim modülü uygulaması. *Ege Eğitim Dergisi*, 19 (1), 135-160. <https://doi.org/10.12984/eggefd.343374> \*TR Indexed
- Pişkin Tunç, M. & Gündoğdu, N. S. (2022). Middleschoolstudents' viewsaboutSTEMactivitiesused in teachingratioandproportion. *Bartın UniversityJournal of Faculty of Education*, 11(3), 647-662. \*TR Indexed



- Polat, Ö. & Bardak, M. (2019). STEM Approach in Early Childhood in Türkiye. *International Journal of Social Science Research*, 8(2), 18-41.
- Pwc ve Türk Sanayicileri ve İşinsanları Derneği (TUSIAD). (2017). 2023'e Doğru Türkiye'de STEM Gereksinimi.
- Reffiane, F., Sudarmin, Wiyanto, & Saptono, S. (2021). Developing an Instrument to Assess Students' Problem-Solving Ability on Hybrid Learning Model Using Ethno-STEM Approach through Quest Program. *Pegem Egitim Ve Ogretim Dergisi*, 11(4), 1–8. <https://doi.org/10.47750/pegegog.11.04.01>
- Sarıgül, M. & Çınar, S. (2021). Mühendislik Tasarım Odaklı Fen Bilimleri Eğitiminde Öğrencilerin Meslek Tercih ve Algılarındaki Değişim. *Erzincan Üniversitesi Eğitim Fakültesi Dergisi*, 23 (3), 888-908. <https://doi.org/10.17556/erziefd.885023> \*TR Indexed
- Sari, U., Celik, H., Pektas, H. M., & Yalcin, S. (2022). Effects of STEM-focused Arduino practical activities on problem-solving and entrepreneurship skills. *Australasian Journal Of Educational Technology*, 38(3), 140–154. <https://doi.org/10.14742/ajet.7293>
- Sari, U., Pektas, H. M., Sen, O. F., & Celik, H. (2022). Algorithmic thinking development through physical computing activities with Arduino in STEM education. *Education And Information Technologies*, 27(5), 6669–6689. <https://doi.org/10.1007/s10639-022-10893-0>
- Savran Gencer, A. & Doğan, H. (2020). Theassessment of thefifth-gradestudents' sciencecriticalthinkingskillsthroughdesign-basedstemeducation. *International Journal of Assessment Tools in Education*, 7(4), 690-714. <https://doi.org/10.21449/ijate.744640> \*TR Indexed
- Savran Gencer, A., Doğan, H. & Bilen, K. (2020). Developingbiomimicry STEM activitybyqueryingtherelationshipbetweenstructureandfunction in organisms. *TurkishJournal of Education*, 9(1), 64-105. <https://doi.org/10.19128/turje.643785> \*TR Indexed
- Sen, C., Ay, Z. S., & Kiray, S. A. (2020). A design-oriented STEM activity for students' using and improving their engineering skills: the balance model with 3D printer. *Science Activities-Projects And Curriculum Ideas In STEM Classrooms*, 57(2), 88–101. <https://doi.org/10.1080/00368121.2020.1805581>
- Sisman, B., Kucuk, S., & Yaman, Y. (2021). The Effects of Robotics Training on Children's Spatial Ability and Attitude Toward STEM. *International Journal Of Social Robotics*, 13(2), 379–389. <https://doi.org/10.1007/s12369-020-00646-9>
- Tanik Onal, N., & Saylan Kirmizigul, A. (2022). A Makey-Makey based STEM activity for children. *Science Activities-Projects And Curriculum Ideas In Stem Classrooms*, 58(4), 166–182. <https://doi.org/10.1080/00368121.2021.2011086>
- Tekerek, B. , Aydemir, H. & Tekerek, M. (2023). Robotik ile matematik ve fen entegrasyonu. *Ordu Üniversitesi Sosyal Bilimler Enstitüsü Sosyal Bilimler Araştırmaları Dergisi*, 13 (1) , 25-52 <https://doi.org/10.48146/odusobiad.1203531> \*TR Indexed
- Tekerek, M. & Tekerek, B. (2018). Integratedinstructionalmaterialanddevelopmentprocesses. *TurkishJournal of Education*, 7 (3), 156-168. <https://doi.org/10.19128/turje.362491> \*TR Indexed
- Tezcan Şirin, G. , Tüysüz, M. & Kaval Oğuz, E. (2022). Ortaokul fen bilimleri ders kitaplarında yer alan etkinliklerin STEM etkinliklerine uygunluğuna dair öğretmen görüşleri. Van Yüzüncü Yıl Üniversitesi Eğitim Fakültesi





Dergisi, Van Yüzüncü Yıl Üniversitesinin Kuruluşunun 40. Yıl Dönümü Şubat Özel Sayısı, 354-386. \*TR Indexed <https://dergipark.org.tr/tr/pub/yyuefd/issue/68424/1068624>

- Timur, B., & Belek, F. (2020). Investigation of the Effects of STEM Activities on Pre-Service Teachers' Self-Efficacy Beliefs and their STEM Intention Levels. *Pamukkale Üniversitesi Eğitim Fakültesi Dergisi-Pamukkale University Journal Of Education*, 50, 315–332. <https://doi.org/10.9779/pauefd.465824>
- Timur, S. , Timur, B. , Yalçinkaya Önder, E. & Küçük, D. (2020). Attitudes of the students attending out-of-school stem workshops towards stem education. *Journal of Theoretical Educational Science*, 13 (2), 334-351. <https://doi.org/10.30831/akukeg.582388> \*TR Indexed
- Tozlu, İ. , Gülseven, E. & Tüysüz, M. (2019). FeTeMM eğitime yönelik etkinlik uygulaması: Kuvvet ve enerji örneği. *Van Yüzüncü Yıl Üniversitesi Eğitim Fakültesi Dergisi*, 16(1) , 869-896. <https://dergipark.org.tr/tr/pub/yyuefd/issue/50700/660068> \*TR Indexed
- Türk Sanayicileri ve İşinsanları Derneği (TUSIAD). (2014). STEM alanında eğitim almış işgücüne yönelik talep ve beklentiler araştırması.
- Türk, N. (2019). Eğitim fakültelerinin lisans programlarına yönelik fen teknoloji mühendislik ve matematik (STEM) öğretim programının tasarlanması, uygulanması ve değerlendirilmesi. *Yayınlanmamış Doktora Tezi, Gazi Üniversitesi, Eğitim Bilimleri Enstitüsü, Ankara*.
- Türkiye Bilimsel ve Teknik Araştırma Kurumu (TUBITAK). (2010). 2011-2016 Bilim ve Teknoloji İnsan Kaynağı Stratejisi ve Eylem Planı.
- Ucgu, M., & Altio, S. (2022). You are an astron eer: the effects of robotics camps on secondary school students' perceptions and attitudes towards STEM. *International Journal Of Technology And Design Education*, 32(3), 1679–1699. <https://doi.org/10.1007/s10798-021-09673-7>
- Uğraş, M. (2017). Okul öncesi öğretmenlerinin STEM uygulamalarına yönelik görüşleri. *Eğitimde Yeni Yaklaşımlar*, 1(1), 39–54.
- Uğraş, M. & Genç, Z. (2018). Investigating preschool teacher candidates' STEM teaching intention and the views about STEM education. *Bartın University Journal of Faculty of Education*, 7(2), 724-744. \*TR Indexed
- Ulay, N., & Aktas, B. (2020). An example implementation of STEM in preschool education: Carrying eggs without breaking. *Science Activities-Projects And Curriculum Ideas In Stem Classrooms*, 57(1), 16–24. <https://doi.org/10.1080/00368121.2020.1782312>
- Umutlu, D. (2022). TPACK leveraged: A redesigned online educational technology course for STEM preservice teachers. *Australasian Journal Of Educational Technology*, 38(3), 104–121. <https://doi.org/10.14742/ajet.4773>
- Uret, A., & Ceylan, R. (2021). Exploring the effectiveness of STEM education on the creativity of 5-year-old kindergarten children. *European Early Childhood Education Research Journal*, 29(6), 842–855. <https://doi.org/10.1080/1350293X.2021.1913204>
- Uslu, S., & Yaman, B. B. (2021). Reflections from the Application of STEM Based Environmental Siphon Activity. *Pamukkale University Journal Of Education*, 53, 457–494. <https://doi.org/10.9779/pauefd.787908>



- Uyar, A. Canpolat, M. ve Şan, İ (2021). STEM merkezindeki öğretmenlerin ve öğrencilerin STEM eğitimi hakkındaki görüşleri: PayaSTEM merkezi örneği. *MANAS Sosyal Araştırmalar Dergisi*, 10(1), 151-170.
- Ürek, H. & Çoramık, M. (2020) A suggestion and evaluation of a STEM activity about friction coefficient for pre-service science teachers. *Journal of Computer and Education Research*, 10(19), 2148-2896. \*TR Indexed
- Yabas, D., & Bozoglu, H. S. (2022). A mentorship model for teacher education: Young STEM researchers and practitioners program. *Turkish Journal Of Education*, 11(1), 36–55. <https://doi.org/10.19128/turje.950335>
- Yabaş, D. & Boyacı, S. (2022). A mentorship model for teacher education: Young STEM researchers and practitioners program. *Turkish Journal of Education*, 11(1), 36-55. <https://doi.org/10.19128/turje.950335> \*TR Indexed
- Yalcin, V. (2022). Design-Oriented Thinking in STEM education Exploring the Impact on Preschool Children's Twenty-First-Century Skills. *Science & Education*. <https://doi.org/10.1007/s11191-022-00410-7>
- Yaşlık, İ. & Akçay, A. O. (2022). İlkokul 2. sınıf serbest etkinlik dersinde stem etkinliklerinin uygulanması: bir eylem araştırması. *Kırşehir Eğitim Fakültesi Dergisi*, 23(1), 1402-1442. \*TR Indexed
- Yazici, Y. Y., Hacıoğlu, Y., & Sari, U. (2022). Entrepreneurship, STEM attitude, and career interest development through 6E learning by DeSIGN (TM) model based STEM education. *International Journal Of Technology And Design Education*. <https://doi.org/10.1007/s10798-022-09780-z>
- Yerdelen-Damar, S., Aksöz, B., Sezer, S., Arabacı, N. & Arıkan, F. (2021). Investigating the interrelationships among science and mathematics achievement, attitude towards stem, and gender. *Bartın University Journal of Faculty of Education*, 10(2), 342-357. \*TR Indexed
- Yetkin, N. & Aküzüm, C. (2022). İlkokul dördüncü sınıf öğrencilerinin öğrenme anlayışları ve stem eğitime yönelik tutumları arasındaki ilişkinin incelenmesi. *İnsan ve Toplum Bilimleri Araştırmaları Dergisi*, 11 (1), 744-769. \*TR Indexed
- Yıldırım, B., & Altun, Y. (2015). STEM eğitim ve mühendislik uygulamalarının fen bilgisi laboratuvar dersindeki etkilerinin incelenmesi. *El-Cezeri Journal of Science and Engineering*, 2(2), 28-40.
- Yıldırım, B. (2020). A Model Proposal for Teacher Training: STEM Teacher Institutes Training Model. *Pamukkale University Journal Of Education*, 50, 70–98. <https://doi.org/10.9779/pauefd.586603>
- Yıldırım, B. (2021). Preschool STEM Activities: Preschool Teachers' Preparation and Views. *Early Childhood Education Journal*, 49(2), 149–162. <https://doi.org/10.1007/s10643-020-01056-2>
- Yıldırım, B. (2022). MOOCs in STEM Education: Teacher Preparation and Views. *Technology Knowledge And Learning*, 27(3), 663–688. <https://doi.org/10.1007/s10758-020-09481-3>
- Yıldırım, B., & Sidekli, S. (2018). STEM applications in mathematics education: the effect of stem applications on different dependent variables. *Journal Of Baltic Science Education*, 17(2), 200–214.
- Yıldırım, B., Akcan, A. T., & Ocal, E. (2022). Teachers' perceptions and stem teaching activities: online teacher professional development and employment. *Journal Of Baltic Science Education*, 21(1), 84–107. <https://doi.org/10.33225/jbse/22.21.84>
- Yorulmaz, A. & Okulu, H. Z. (2022). Sınıf öğretmeni adaylarının STEM eğitime yönelik inançları, anlayışları ve niyetleri: Bir ölçme aracı uyarlama çalışması. *Batı Anadolu Eğitim Bilimleri Dergisi*, 13(1), 600-617. \*TR Indexed





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- Yuceler, R., Aydin-Gunbatar, S., & Demirdogen, B. (2020). Stop bridge collapse: a STEM activity about preventing corrosion of metals. *Science Activities-Projects And Curriculum Ideas In Stem Classrooms*, 57(4), 154–164. <https://doi.org/10.1080/00368121.2020.1850408>
- Yucelyigit, S. (2021). Effects of Workshops on the Early Childhood Educators' Perceptions of STEM Practices. *Journal Of Education And Future-Egitim Ve Gelecek Dergisi*, 20, 37–48. <https://doi.org/10.30786/jef.792028>
- Yüksel, A. (2022) Investigation of pre-service scienceteachers' learningexperiences on educationalroboticsapplications. *Journal of ComputerandEducationResearch*, 10(19), 2148-2896. \*TR Indexed



# THE STATE OF THE ART ANALYZE ABOUT STEM EDUCATION PRACTICES IN SLOVENIA

## EXECUTIVE SUMMARY

Report WP2 is a comprehensive study that explores STEAM (Science, Technology, Engineering, Arts, and Mathematics) education in Slovenia, with a particular focus on incorporating sustainable practices and the green transition. The introduction highlights Green STEAM, which seamlessly integrates environmental awareness throughout all levels of learning.

The subsequent section delves into the Slovenian education system, outlining its unique characteristics. This system encompasses primary, secondary, and tertiary education, along with adult education opportunities.

The heart of the report is in the chapter, where a detailed examination of green STEAM education's current state in Slovenia takes place. While green transition and sustainability are partially present in various educational stages, their strongest integration is found in tertiary education and research institutions. Despite this, there's a noticeable lack of systematic inclusion of green technologies and sustainability across educational frameworks. Encouragingly, multiple initiatives are underway at different education levels to address this gap on a national scale.

The final chapter presents a blueprint for a STEAM education and training monitoring framework. This framework enables a comparison between Slovenian students and global educational approaches. An important finding emerges from this assessment: Slovenian educational methods and test results surpass the average.

Crucially, a significant conclusion arises from this analysis. Educational approaches and test outcomes go beyond the norm, indicating the system's adeptness in assimilating novel skills relevant to contemporary environmental issues. This readiness spans the entire spectrum of education, from early years to adulthood, demonstrating the education system's responsiveness to urgent ecological concerns.

## INTRODUCTION



Green STEAM, which stands for Science, Technology, Engineering, Arts, and Mathematics with a focus on environmental consciousness, eco-friendly technologies, and sustainable practices, holds immense importance for the future society. It plays a crucial role in promoting sustainability, preserving the environment, and mitigating climate change. The integration of environmental awareness into STEAM education fosters Sustainable Innovation, Climate Change Mitigation, Environmental Awareness, Cross-disciplinary Collaboration, Green Career Opportunities, Resilient Communities, and Global Impact.

Through green STEAM education, individuals should be equipped with the knowledge, skills, and mindset necessary to tackle environmental challenges and create a sustainable and resilient world. By encouraging the application of arts, technology, and scientific principles in an environmentally conscious manner, we inspire the next generation to become environmentally responsible innovators. This, in turn, leads to a brighter future for everyone, with a focus on harmonious coexistence with nature and a commitment to global sustainability.

## SLOVENIAN EDUCATION SYSTEM

The education system in Slovenia comprises three main sections: primary, secondary, and tertiary education, with additional provisions for adult and special needs education.<sup>1</sup> For detailed schematics see the APPENDIX – *Education system in Slovenia*

1. Primary education encompasses a variety of institutions such as public and private kindergartens, basic schools, those with adapted education programs, music schools, and educational institutions catering to children with special educational needs. This stage covers early childhood education and care, basic education, and music education.

2. Secondary education is delivered through upper secondary schools and secondary schools, each offering distinct pathways. Students can choose between general or vocational technical education and secondary professional or technical education.

3. Tertiary education is available through both public and private institutions and includes higher post-secondary vocational education and higher education. Higher vocational colleges offer short-cycle higher vocational education, while faculties, academies, and independent higher education institutions provide higher education options.



Additionally, Slovenia also emphasizes adult education and Special needs education, which are organized by private entities or non-profit organizations, providing opportunities for individuals seeking further development or requiring specialized support. By structuring the education system in this manner, Slovenia aims to provide a comprehensive and diverse learning experience for its citizens, catering to various interests, abilities, and needs. The focus on both general and specialized education paths equips students with the necessary skills and knowledge for future success, while adult education and special needs education initiatives contribute to a more inclusive and accessible learning environment for all members of society.

## STATE-OF-THE-ART – (GREEN) STEAM EDUCATION IN SLOVENIA

STEAM education in Slovenia has been gaining significant attention and recognition in recent years and it represents an interdisciplinary approach to learning that encourages creativity, critical thinking, problem-solving, and collaboration among students. In Slovenia, the implementation of STEAM education has been driven by the recognition of the importance of equipping students with skills that are essential in the 21st century workforce. The government, educational institutions, and various non-governmental organizations have been actively promoting STEAM initiatives to foster innovation and prepare the next generation for a technology-driven and rapidly changing world.

One of the primary goals of STEAM education in Slovenia is to bridge the gap between traditional academic subjects and real-world applications. By integrating science, technology, engineering, arts, and mathematics, students are encouraged to approach problems in a holistic manner, allowing them to better understand complex issues and develop comprehensive solutions.

Slovenia has been investing in the professional development of teachers to ensure they have the necessary skills and knowledge to effectively implement STEAM methodologies in their classrooms. Workshops, training programs, and networking opportunities have been organized to support educators in incorporating STEAM principles into their teaching practices. Moreover, the Slovenian government has collaborated with private sector companies and research institutions to provide students with access to cutting-edge technology and real-world experiences. These partnerships have resulted in various mentorship programs, internships, and school-industry collaborations, giving students the chance to work



on actual projects and learn from professionals in different fields. Furthermore, initiatives promoting diversity and inclusion in STEAM education have also gained traction in Slovenia. Efforts are being made to encourage more girls and underrepresented groups to pursue STEAM-related fields and careers, aiming to create a more diverse and inclusive workforce in the future.

STEAM education in Slovenia is on a positive trajectory, as it continues to empower students with the skills, knowledge, and mindset needed to thrive in a technology-driven society. With a focus on hands-on learning, interdisciplinary approaches, and industry partnerships, Slovenia is positioning itself to foster a new generation of innovative thinkers and problem solvers, making significant contributions to both local and global challenges.

### PRE-SCHOOL EDUCATION (Primary) (age 1 to 6)

The curriculum for kindergartens has remained relatively unchanged since its establishment in 1999.<sup>2</sup> Primarily focused on the fundamentals of art and mathematics, it employs a playful approach to early learning. However, a transformative shift is evident in 2022, marked by the release of revised guidelines for kindergarten curriculum renewal.<sup>3</sup> Notably, these revisions place a significant emphasis on sustainability as a cornerstone. This update underscores the critical role of instilling sustainable development values, particularly fostering a sense of responsibility towards oneself, fellow human beings, other living entities, and the surrounding environment within the realm of childhood education. As part of a larger initiative funded by the Mechanisms for Recovery and Resilience (NOO - Mehanizma za okrevanje in odpornost),<sup>4</sup> the rejuvenation of educational programs coincides with the revitalization of key foundational documents, encompassing the curriculum for kindergartens, lesson plans, and knowledge catalogs. This comprehensive endeavor operates under the imperative of accomplishing its goals by the deadline of December 31, 2025.

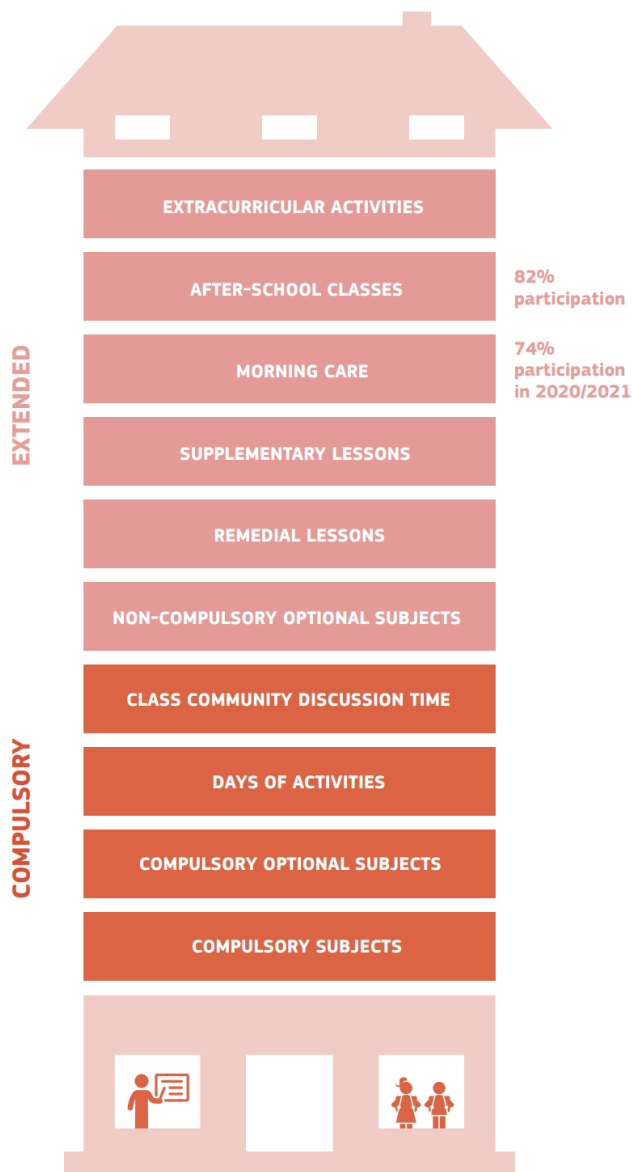
### BASIC EDUCATION (Primary& Lower secondary) (age 6 – 15)

Primary and lower secondary education in Slovenia follows a unified nine-year structure within a single basic school system, catering to students aged 6 to 15 years. This educational



framework is offered by both public and private schools, with private basic schools accounting

### Basic school programme



for a minority share of students (less than 1%). Additionally, educational institutions catering to students with special educational needs and adult education organizations are also part of the educational landscape. Basic school program is composed of Compulsory and Extended programs (Figure 1)<sup>5</sup>. For detailed program see APPENDIX for *Basic Education school program*.

Aligned with the stipulations of the Constitution of the Republic of Slovenia, basic school education is not only mandatory but also financially supported by the state.

First educational cycle (age 6 – 9)

Within the First Educational Cycle, a quartet of compulsory courses emerges, aptly classified as STEAM subjects, encapsulating Mathematics, Fine Art, Music, and the Fundamentals of the Environment (*slo.* "Spoznavanje okolja"). Notably, the curriculum

of the Fundamentals of the Environment course extends its purview to encompass green technologies as well. The course of environmental topics serves as a catalyst for fostering education and training aimed at sustainable development. This course comprehensively embraces interconnected facets of the environment, economy, and society. The curriculum of this course is rooted in foundational concepts that not only enhance understanding within disciplines such as natural sciences and technology, but also extend into the realms of society. This integration takes place within the second educational cycle.



Furthermore, it spans across subjects involving natural sciences, technology, and social sciences in the subsequent educational phase, solidifying its multi-dimensional impact.

#### Second educational cycle (age 9 – 12)

The spectrum of subjects constituting the realm of STEAM education undergoes expansion within the second cycle, now encompassing an array of disciplines: Mathematics, Fine Art, Music, Natural Science (*s/o. "Naravoloslovje"*), Natural Science and Technology (*s/o. "Naravoslovje in Tehnika"*), and Engineering and Technology (*s/o. "Tehnika in Tehnologija"*). Notably, all subjects pertaining to the domain of natural sciences, engineering, and technology incorporate references to green technologies within their curricula. This integration creates a vertical interconnectedness between them and Fundamentals of the Environment (*s/o. "Spoznavanje okolja"*) from First educational cycle. In the realm of technical courses, students delve into the fundamental framework of technology, which is delineated by four interconnected domains:

- **Technical Resources:** This domain encapsulates an array of vital components including processing tools, machinery, energy converters, transmission systems, movements, and mechanisms for handling information.
- **Technological Processes:** Within this realm, students explore the various facets of technological manipulation such as shaping, transformation, cutting, joining, surface treatment, and related operations.
- **Organizational Dynamics:** This domain encompasses the dynamic interplay of problem analysis and product development, serving as the driving force behind efficient work methodologies.
- **Economic Considerations:** Here, the evaluation of products and work takes center stage, shedding light on the economic dimension of technological endeavors.

Together, these domains collectively enrich the learning journey and create a holistic educational experience. Notably, within this landscape, energy converters assume a pivotal role. They delve into Energy and Storage technologies, offering a doorway to the realm of alternative green technologies. This comprehensive approach equips students not only with knowledge but also the awareness of the transformative potential of sustainable energy solutions.

On the other hand, within the realm of natural sciences, students embark on a journey of learning and cultivating a profound comprehension of fundamental natural science concepts and principles. These





foundational elements serve as the bedrock for comprehending the intricate tapestry of phenomena in the natural world. Moreover, students delve into the intricate interplay between living and non-living aspects of nature, unraveling the complex relationships that exist between the structure, properties, and functions of these dynamic systems. Throughout their exploration of science, students gain insights into the profound significance that natural sciences hold for the advancement of humanity. This process not only cultivates knowledge but also nurtures attitudes and perspectives toward themselves, their environment, and the broader natural world. It instills an acute awareness of the imperative of responsible behavior, underpinning the care of personal safety and the well-being of others. Through this holistic approach, students are empowered to forge a symbiotic relationship with nature, fostering a sense of stewardship and underscoring the vitality of conscientious actions for the collective welfare. All of this knowledge serves as a crucial foundation for the development of modern green technologies.

Concluding the second educational cycle, students' proficiency in core subjects—Slovene language, Mathematics, and English—is assessed through the National Knowledge Test (NPZ). This assessment is obligatory for all students.

Third educational cycle (age 12 – 15)

The distinctive feature of the third educational cycle is that only subject-specialist teachers (*s/o. Predmetni pouk*) are responsible for instruction. This unique arrangement fosters more comprehensive and in-depth exploration across all fields, including the STEAM courses. Additionally, students are mandated to opt for a minimum of two hours' worth of elective courses annually.

In this advanced phase, the canvas of subjects aligned with the STEAM framework widens further, encompassing Physics, Chemistry, and Biology. Alongside these, students enjoy the freedom to select two elective courses from an extensive assortment of options. Essentially, these electives are divided into two sets: one covering Social Sciences and Humanities, and the other focusing on Natural Science and Technical domains. Among these courses are Mathematical Workshops, Nutritional Practices, Material Processing, Chemistry and Physics Experiments, Engineering and Computational Principles, as well as Geometry and Technical Drawing (involving 3D printing and modeling). Notably, several of these offerings establish either direct or indirect ties to green technologies.

An additional significant aspect of basic education comprises mandatory activity days (Figure 1), encompassing excursions, nature outings, and technical sessions. During these periods, students are provided with chances to explore research laboratories, institutions, museums, and more. Much like the



second educational cycle, students in the third cycle undergo assessment via the National knowledge test (NPZ). This evaluation covers proficiency in Slovene language, Mathematics, and a third subject determined by the Government. This mandatory assessment applies to all students.

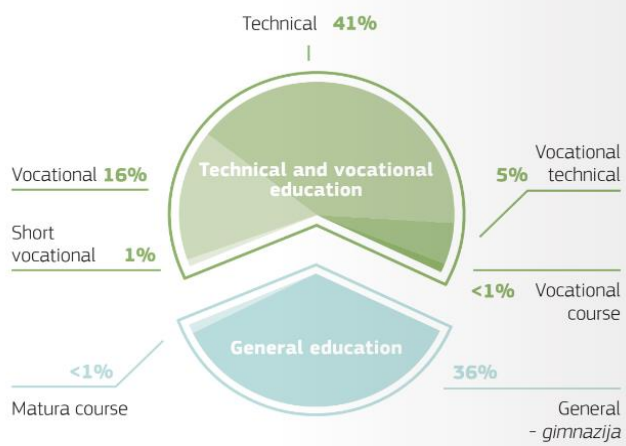
### UPPER SECONDARY EDUCATION (Secondary) (age 15 – 19)

After completing their mandatory primary education, students, typically at around the age of 15, can opt to continue their academic path at the upper secondary level, selecting a school and program that aligns with their preferences. This phase typically spans from two to five years for completion.

Moreover, attaining an upper secondary education qualification remains attainable during adulthood through regular programs that incorporate specialized organizational adjustments tailored for adult learners. However, the enrollment of candidates may be constrained if the number surpasses the school's capacity.

The framework of upper secondary education operates within a centralized structure. Consequently, determinations concerning school establishment, funding, and educational programs are formulated at the national level. While schools and educators uphold autonomy in executing mandated programs, they also wield independence in matters pertaining to human resource selection and management.

**Enrolment by type of upper secondary education programme, 2015**



**Figure Enrolment by type of upper secondary education programme, 2015**

Upper secondary education is organized into two streams: general education and technical and vocational education. Among the students, approximately one-third opt for general education, while the remaining two-thirds opt for technical and vocational education (as shown in Figure 2).<sup>6</sup> The duration of general programs spans four years, while technical and vocational education can vary in length, spanning 2, 3, or 4 years. The latter is further categorized into different tracks, including Technical Programs (4 years), Short Vocational Programs (2 years), Vocational Programs (3 years), and Vocational Technical Programs (2 years).



### General Education (Matura)

The primary benefit of General high school education (*slo.* “Gimnazija”) lies in its comprehensive knowledge spectrum. This knowledge equips students with the prerequisites for pursuing further education at universities, both in Slovenia and across the globe. Completion of a gymnasium program, along with achieving a general Matura, is a prerequisite for those aspiring to pursue higher education at universities and certain colleges.

The curriculum for general education comprises a blend of compulsory and elective courses. Within the realm of STEAM, pivotal subjects are incorporated as compulsory components, including Fine Art, Biology, Physics, Geography, Informatics, Chemistry, and Mathematics. Similarly, an array of elective courses is available, presenting students with more advanced or in-depth iterations of Biology, Physics, Geography, Informatics, Chemistry, and Mathematics.

The current study program briefly touches upon green technologies in different sections, lacking in-depth exploration. Addressing this, a specialist working group has drafted foundational principles for revamping curricula in elementary and high schools.<sup>7</sup> Their key observation is that the 21st century demands education to reflect significant societal changes that influence society's essence. This era emphasizes resolving environmental and societal issues such as digitization's impact, resource implications of consumer choices, and environmental preservation. Thus, fostering sustainable development awareness and digital competence in the youth becomes pivotal.

Moreover, a transformative shift is underway wherein machines transcend their traditional confines of physical labor and increasingly contribute to human cognitive capacities. This reevaluation of their function necessitates a comprehensive comprehension of machine dynamics, akin to the established scientific disciplines. As a result, the curriculum's evolution endeavors to foster environmental consciousness, digital adeptness, and a nuanced comprehension of machine intricacies, aligning seamlessly with the transformative landscape of the 21st century. These insights underscore the imperative of incorporating Green STEAM into the education system.

### Technical and Vocational Education

Technical and vocational education presents a specialized array of STEAM courses that delve deeply into distinct technical and natural fields. This facet of education provides a



concentrated focus on diverse areas, offering students a comprehensive understanding of various technical and scientific disciplines. In addition to the conventional subjects like Mathematics, Music, Fine Art, Biology, Chemistry, Physics, and Informatics, this avenue introduces a range of specialized courses closely aligned with the realms of Green STEAM.

These specialized courses encompass a multitude of disciplines that are intrinsically connected to the domains of sustainability and environmental consciousness. Notable examples include Biotechnology, Electrical Engineering, Materials Science, Mechanics, Computer Science, Electronic Systems, Construction, Agriculture, Woodworking, Microbiology, Spatial Modeling, Computer Systems and Networks, Mechanical Engineering, Laboratory Exercises, Astronomy, Selected Chapters in Biotechnology, Creative Entrepreneurship, Research Papers and Other Products, Project Work Incorporating Research Methodologies, Environmental Studies, and Education for Solidarity. The list, though extensive, merely scratches the surface of the comprehensive offerings.

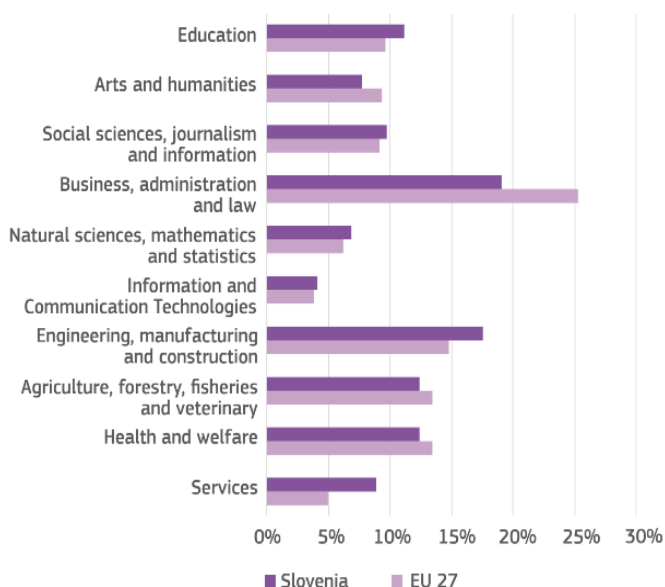
Despite this expansive selection, the core challenge remains that the current curricula lack a holistic perspective when it comes to comprehending green technologies. The intricate interplay between various STEAM components and their application to sustainability-focused fields such as renewable energy, resource management, and ecological preservation often gets fragmented. This deficiency underscores the need for a unified approach that bridges the gaps, providing students with a profound grasp of green technologies within a broader educational context.

## HIGHER AND SHORT-CYCLE HIGHER VOCATIONAL EDUCATION (Tertiary)

Following the Bologna reform, Slovenia's tertiary education structure comprises three cycles: the 1<sup>st</sup> cycle - Bachelor's (3 years), the 2<sup>nd</sup> cycle - Master's (2 years), and the 3<sup>rd</sup> cycle - Doctoral. The country is home to four distinguished universities: the University of Ljubljana, the University of Maribor, the University of Primorska, and the University of Nova Gorica.



These universities are united by a shared mission centered around fostering interdisciplinary



**Figure Distribution of tertiary education graduates by broad field of education, 2020**

exploration, innovation, and creativity. They are dedicated to empowering students as critical thinkers and active contributors to society, emphasizing the essential connection between science, art, and societal progress. Through adaptable and dynamic educational methodologies, these institutions strive to equip graduates with the capabilities necessary to confront the intricate challenges of the contemporary world, including the realm of green technologies (Figure 3)<sup>8</sup>.

Green technologies are well represented within various study programs as well as within the research groups at the

universities.

All four universities establish robust connections with public research institutes (Jozef Stefan Institute, National Institute of Chemistry, National Institute of Biology, The Geological Survey of Slovenia, Slovenian Forestry Institute, Institute for Hydraulic Research, The Institute of Metals and Technology, Agricultural Institute of Slovenia, Educational Research Institute, Urban Planning Institute of the Republic of Slovenia, Slovenian National Building and Civil Engineering Institute, etc.) and select private entities, as well as house formidable research and development units within the corporate realm. The synergy between a rich scientific heritage and a contemporary research and development structure drives substantial engagement in the fields of green technologies and sustainability. Despite Slovenia's relatively modest population of around 2 million, the nation's scientific community comprises over 11,000 dedicated researchers who contribute significantly, resulting in 1.346 international scientific co-publications per 100,000 individuals.



Slovenia's deep appreciation for science and education is evident in the remarkable count of new doctoral graduates per 100,000 residents, an impressive figure of 355. This unwavering commitment to scholarly pursuits is deeply ingrained in the country's culture, underscoring the pivotal role that science and research play in shaping Slovenia's society. This shared dedication signifies that the critical mass needed to embrace and implement innovative green technologies is substantial enough to drive transformative changes across various sectors as well as down the education vertical.

### Green Education and Research at University of Ljubljana

Slovenia, notably the University of Ljubljana, proudly stands as a distinguished member of the EU STEM Coalition. This coalition functions as a pan-European network devoted to advancing STEM (Science, Technology, Engineering, Mathematics) education across the continent. Its overarching mission is to craft and implement STEM education policies and strategies that not only drive economic growth but also create widespread opportunities and enhance overall well-being. Collaborating closely with policymakers, educational institutions, and industry stakeholders, the coalition is committed to championing innovative approaches to educational delivery. Furthermore, it actively seeks out and disseminates evidence-based solutions to address the pressing issue of skill mismatches within the STEM fields. By tackling challenges ranging from the shortage of skilled STEM professionals to fostering robust partnerships between educational bodies, corporations, and governments, the coalition offers an unparalleled platform. At the core of its activities lies the provision of a unique forum and knowledge hub, serving as a repository for data-driven analyses, sharing of best practices, and direct support. Through this multifaceted approach, the coalition not only envisions a future with an abundance of STEM talent but also catalyzes collaboration that extends beyond traditional boundaries, ensuring the continued advancement of STEM education and its myriad benefits.<sup>9</sup>

The University of Ljubljana is the oldest and largest higher education and scientific research institution in Slovenia. The university was founded in 1919. It has approximately 38,000 undergraduate and postgraduate students and employs approximately 6,000 higher education teachers, researchers, assistants and administrative staff in 23 faculties and three arts academies.<sup>10</sup> The University of Ljubljana stands out for its exceptional programs in both social and natural sciences, as well as technical studies.



These programs are meticulously designed in accordance with the principles set forth in the Bologna Declaration. The institution remains at the forefront of advancements in arts, sciences, and technology, both within the country and on the global stage. Recognizing the pressing need for STEM expertise in Slovenia, the University of Ljubljana is actively engaged in a diverse array of outreach initiatives, aimed at fostering a robust pipeline of STEM talent. These initiatives encompass:

- Collaborative efforts through Quadhelix partnerships, bringing together educational institutions, industries, non-profit organizations, and government bodies.
- Engaging STEM activities within MakerLabs and FabLabs, empowering hands-on exploration and creativity.
- Orchestrating summer and winter schools, along with CAMPs, tailored for students in elementary and secondary education.
- Playing a key role in formulating a comprehensive national STEM strategy in conjunction with other stakeholders.
- Offering specialized training sessions for students, parents, and educators alike.
- Promoting awareness about promising STEM careers and showcasing inspirational role models.
- Undertaking research ventures focused on pressing issues such as Sustainable Innovation, Climate Change Mitigation, Environmental Awareness, Cross-disciplinary Collaboration, Green Career Opportunities, Resilient Communities, and Global Impact.

While these efforts hold immense significance, it's crucial to recognize that they currently don't fully come together as a well-integrated and organized approach to effectively address the complex challenges of Green STEAM. Nevertheless, a shining model of commitment to green challenges is evident at the University of Ljubljana. Here, a comprehensive approach to tackling a range of green challenges is built upon three main pillars:

- a) Enriched or dedicated Study Programs:
- b) Cutting-edge Research Endeavors:
- c) Impactful Project Ventures:





### Study Programs

The University of Ljubljana is forging ahead by infusing sustainability-oriented content and principles across its diverse array of study programs. Students are being equipped not only with foundational knowledge but also with a profound understanding of the interconnectedness between their chosen fields and the pressing environmental concerns. Through thoughtfully curated coursework, students are empowered to become proactive agents of change, steering industries towards greener horizons.

University of Ljubljana and its Faculties are fostering several study programs that are devoted to Delivering the European Green Deal with the aim to transform the economy and societies.<sup>11</sup> This comprehensive initiative aims to drive transformative changes in both economies and societies. Across all three academic cycles, a majority of the existing study programs now offer a selection of courses that center around the principles of the green transition. Refer to Table 1 for an overview of these efforts.

**Table 1 University of Ljubljana member Faculties that offer courses related to Sustainability.**

Faculty:	Study program:	Study cycle	Courses:
Faculty of Chemistry and Chemical Technology	Chemical sciences	3.	<ul style="list-style-type: none"> <li>Selected topics in environmental engineering</li> <li>Selected topics in materials for new energy sources</li> </ul>
	Chemistry	2.	6 different courses related to Materials for Energy Storage and Conversion. Detailed curriculum <sup>12</sup>
Faculty of Mechanical Engineering	Mechanical Engineering	3.	3 different fields related to Green Transition: <ul style="list-style-type: none"> <li>Machine Design and Mechanics Engineering Science,</li> <li>Energetical, Process and Environmental Engineering Sciences,</li> </ul>



			<ul style="list-style-type: none"> <li>Production Engineering Sciences, Cybernetics and Mechatronic</li> </ul>
Faculty of Electrical Engineering	Electrical Engineering	3.	<ul style="list-style-type: none"> <li>Photovoltaics</li> <li>Energy Conversions and Environment</li> <li>Intelligent buildings</li> <li>Intelligent mobile transport systems</li> </ul>
	Advanced Power Systems	2.	Several courses see reference <sup>13</sup>
Biotechnical Faculty, Faculty of Arts, Faculty of Chemistry and Chemical Technology, Faculty of Civil and Geodetic Engineering, Faculty of Law, Faculty of Maritime Studies and Transport, Faculty of Mathematics and Physics, Faculty of Mechanical Engineering, Faculty of Medicine, Faculty of Natural Sciences and Engineering, Faculty of Social Sciences, School of Economics and Business, Veterinary Faculty	Interdisciplinary doctoral programme in Environmental protection	3.	Several courses see reference <sup>14</sup>
Faculty of Education	Teacher Education and Educational Sciences	3.	<ul style="list-style-type: none"> <li>Semantic Technology</li> </ul> <p>and the Virtual Learning Environment</p>



Biotechnical Faculty	Forestry and Renewable Forest Resources	1.	<ul style="list-style-type: none"> <li>• Forest Entrepreneurship</li> <li>• Landscape ecology</li> <li>• Forest harvesting</li> <li>• Forest Ecology and Tending</li> <li>• Introduction to Ecology</li> <li>• Production of Forest Reproductive Material</li> </ul>
	<ul style="list-style-type: none"> <li>• Economics of Natural Resources</li> <li>• Ecology and Biodiversity</li> <li>• Forestry and Forest Ecosystem Management</li> <li>• Biotechnology</li> </ul>	2.	Several courses see reference <sup>15</sup>
Biotechnical Faculty, Faculty of Computer and Information Science, Faculty of Electrical Engineering, Faculty of Health Sciences, Faculty of Mechanical Engineering	Biosciences	3.	Several courses see reference <sup>16</sup>
Faculty of Computer and Information Science	Computer and Information Science	3.	<ul style="list-style-type: none"> <li>• Selected Topics in Artificial Intelligence 1</li> <li>• Selected Topics in Artificial Intelligence 1</li> </ul>
Faculty of Natural Sciences and Engineering	Getechnology	2.	<ul style="list-style-type: none"> <li>• Geothermal energy</li> <li>• Waste treatment</li> <li>• Energy politics</li> <li>• Clean technologies</li> </ul>



			<ul style="list-style-type: none"> <li>• Geothermal research and underground fluid modelling</li> </ul>
	Materials and Metallurgy	2.	<ul style="list-style-type: none"> <li>• Industrial ecology and energetics</li> </ul>
	Geology	2.	<ul style="list-style-type: none"> <li>• Environmental mineralogy</li> <li>• Protection and management of groundwater resources</li> </ul>
Faculty of Civil and Geodetic Engineering, Faculty of Natural Sciences and Engineering	Built Environment	3.	<ul style="list-style-type: none"> <li>• Applied Environmental Geochemistry</li> <li>• Assessment of</li> <li>• Water Management Impact on River Basin</li> <li>• Protection of Water Environment</li> <li>• Climate adapted buildings</li> </ul>

### Research Endeavors

UL boasts a formidable team of over 3,500 researchers whose collective efforts have garnered remarkable recognition. According to data gleaned from the Thomson-Reuters Web of Knowledge database, faculty members and researchers at the University of Ljubljana consistently contribute to nearly half of all globally renowned scientific publications emerging from the Republic of Slovenia.

In recent years, UL has ascended to exceptional heights. It proudly resides within the top 3% of the world's most accomplished universities according to The Times Higher Education ranking. Additionally, in the esteemed Shanghai Ranking, UL secures a place among the top 500 research universities worldwide. Its influence extends beyond rankings, evidenced by its strong presence in terms of international resonance, as reflected by citations of its scientific publications. A remarkable showcase of its pinnacle research accomplishments is presented annually during the University Week.



This institution provides a thriving research milieu alongside modern cutting-edge equipment,<sup>17</sup> both to its resident researchers and those visiting. Such an environment is conducive to the pursuit of groundbreaking research breakthroughs and fostering innovation.

The University's commitment to pioneering research is manifesting prominently in its initiatives focused on green initiatives too. By fostering an environment conducive to innovative exploration, researchers are delving into the depths of complex challenges, unraveling intricate relationships between the environment and technology. These investigations are yielding insights that have the potential to catalyze transformative breakthroughs, reshaping industries and practices for a more sustainable future.

### *Project Ventures*

Recognizing that practical implementation is an indispensable component of sustainable progress, the University of Ljubljana is not merely confining itself to theoretical pursuits. Instead, it's engaging in hands-on project endeavors that bridge the gap between conceptualization and real-world application. Collaborative projects, spanning disciplines, are channeling the collective wisdom of academia towards tangible solutions. These projects don't just remain confined to campus but have the potential to radiate positive change throughout local and global communities. Report on EU tenders and applications for EU projects in 2021 and the current status of EU projects at University of Ljubljana is very telling of many ongoing research activities related to sustainability.<sup>18</sup>

Probably the biggest project and the most relevant at University of Ljubljana is project ULTRA – reform of the university curriculum for a sustainable society (duration of the project: from 01.07.2022 until 31.12.2025, project value: 25.620.588,00 EUR). The investment is strategically designed to propel forward the implementation of pivotal pilot projects that focus on revamping the curricula across 29 Faculties and their professional study programs.

This comprehensive endeavor by University of Ljubljana spans a dynamic landscape, establishing inter- and multidisciplinary pilot projects that synergistically bring together multiple stakeholders in each initiative. This collaborative approach empowers University of Ljubljana to holistically confront the intricate challenges posed by the green and digital transition across a diverse spectrum of academic domains. Moreover, it positions University of Ljubljana to effectively address the societal and economic intricacies connected to the pervasive green and digital transformation reshaping our world.



A total of 11 pilot projects will be executed within the framework of this initiative, each honing in on distinct facets of this transformative journey:

1. Natural Resources and Food
2. Digital and Green Renovation of study programs
3. Innovative Learning Environments
4. Sustainable Space
5. Environmental and Digital Literacy
6. Environmental Technologies
7. The Digital Future: Navigating the trajectory of our digital landscape and its impact
8. Lifelong Learning and Micro-credentials
9. Educational Ecosystem for Digital Competences
10. Strengthening Learning and Teaching for Sustainability
11. Sustainable and Digital University of Ljubljana: Pioneering sustainable and digital practices within the university itself.

This strategic venture signifies UL's resolute commitment to not only enhancing education but also to actively contributing to the advancement of a greener, digitally informed society. Through these pilot projects, the University of Ljubljana is setting the course for a comprehensive transformation that reverberates beyond academia, nurturing sustainable progress on various fronts.

In a world where the Green STEAM challenges are growing in complexity and urgency, the University of Ljubljana's multi-pronged approach is an embodiment of a concerted effort to surmount these challenges. However, it's essential to acknowledge that this journey is ongoing, and the University remains dedicated to continually refining and expanding its initiatives. As strides are made within each of these pillars, the vision of a harmonious coexistence between human advancement and ecological equilibrium becomes increasingly attainable.

[Adult education and life-long learning](#)



In the rapidly evolving world of green technologies, the idea of lifelong learning carries significant weight. As this field progresses swiftly, people of all ages and from diverse backgrounds are acknowledging the need to continuously update their knowledge and skills. Lifelong learning acts as a bridge that spans generations, making sure that everyone can tap into the latest insights, methods, and advancements in green technologies.

The Slovenian Institute for Adult Education stands out as a prominent institution in the field of andragogy, with a keen awareness of the importance of green practices and sustainability. They're actively involved in several ongoing projects geared toward equipping the adult generation with the emerging technologies and tools that will shape our future. These projects encompass both national and international endeavors. Two especially notable initiatives are "Education for Sustainable Development,"<sup>19</sup> which was introduced in 2007 and is still evolving, and "Lifelong Learning of Adults for Sustainable Development and Digital Breakthrough."<sup>20</sup>

These projects embody Green STEAM education, epitomizing the dynamic interplay between environmental consciousness and personal growth. In a world where sustainable practices are increasingly vital, adults are enthusiastically seizing the chance to expand their knowledge. Whether it's comprehending renewable energy systems, mastering sustainable design principles, or navigating the intricacies of eco-friendly manufacturing, adult learners are immersing themselves in a wide range of topics that directly contribute to a more sustainable future.

What sets adult learners apart is their practical life experience, enriching the learning environment. This fusion of hands-on knowledge with formal education enhances the conversation, nurturing a holistic grasp of how green technologies can seamlessly integrate into various sectors, even within their homes. Ultimately, this approach embodies our shared dedication to nurturing a generation of environmentally conscious individuals, armed with the know-how and tools to drive positive change. This commitment extends beyond personal lives, influencing the global stage as well. The journey of lifelong learning in green technologies becomes a conduit for shaping a brighter, more sustainable future for all.





## EDUCATION AND TRAINING MONITOR IN STEAM

Assessing the quality of education and gauging innovative methodologies within the educational sphere is an intricate and often underappreciated endeavor. Yet, within this complex landscape, there exist studies that offer statistical perspectives on ongoing efforts in the realm of STEAM education in Slovenia. The capacity to effectively measure innovation stands as a crucial cornerstone for devising educational enhancement strategies.

In the field of quantifying inventive approaches, an analysis conducted in 2014 yielded enlightening findings. This examination revealed that among 29 countries included in the study, Slovenia secured the 9th position in terms of overall innovation in education (as depicted in Figure 4). This positioning offers a quantitative glimpse into Slovenia's progressive strides in integrating innovation within its educational framework.<sup>21</sup>

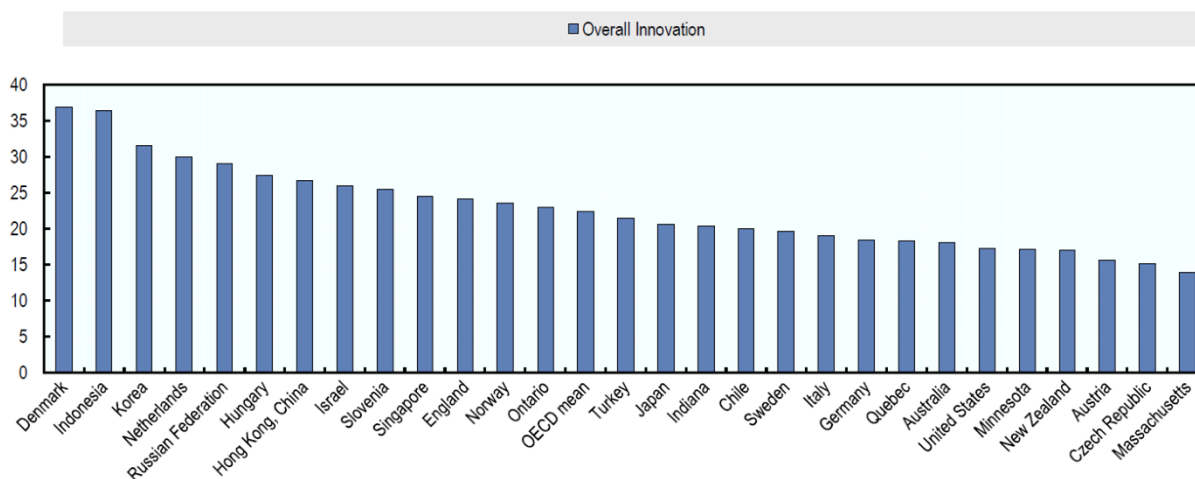
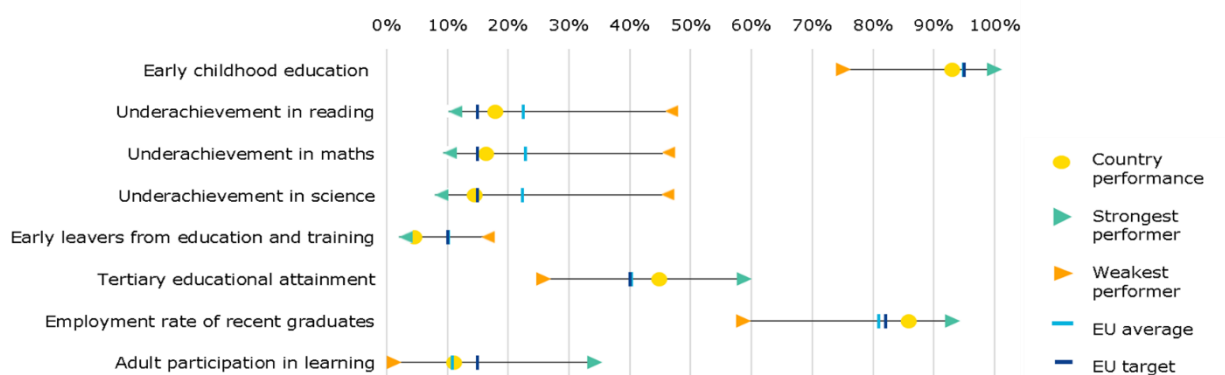


Figure Overall composite innovation index, 2000-2011

Expanding on the Education and Training Monitor 2020 report,<sup>22</sup> as well as insights gleaned from the OECD's Programme for International Student Assessment, it's evident that Slovenia has secured a remarkably high standing in terms of student performance in STEAM subjects. Delving into specifics, it's notable that Slovenian students have demonstrated exceptional prowess, particularly excelling in the domains of Science and Mathematics (Figure 5). These students have consistently outperformed their EU counterparts in these crucial disciplines, showcasing a depth of understanding and skill that surpasses the



regional average. Furthermore, the proficiency of Slovenian students in Science has even surpassed the EU's predefined target, signifying an outstanding level of attainment and proficiency. This accomplishment underscores not only the dedication of educators and institutions but also the commitment of the nation to fostering a well-rounded and advanced educational landscape.



**Figure** Position in relation to strongest and weakest performers. Slovenia position is labeled with yellow dot.

Amid these commendable achievements, it's important to acknowledge that this success is a result of concerted efforts across various sectors. Effective teaching methodologies, robust curriculum design, and the emphasis on hands-on learning experiences have all played pivotal roles in elevating the educational standards in Slovenia.

Beyond the numbers, this achievement resonates on a broader scale. It reflects the potential of a nation to equip its youth with the skills and knowledge that will shape the trajectory of future National and EU directions toward sustainable society. As the global landscape becomes increasingly reliant on STEAM disciplines, Slovenia's commitment to excellence in these subjects positions its students to become future leaders, innovators, and contributors to green fields that drive societal progress.

However, the path ahead is still unfolding, and this impressive accomplishment provides a sturdy groundwork for an unceasing journey of enhancement. As educational systems continually evolve and the requisites of the contemporary world undergo transformation, the unwavering pursuit of excellence remains a guiding principle. This unwavering commitment to nurturing critical thinking, problem-solving, and creative capacities within students ensures that Slovenia stands ready to uphold its notable standing in the domain of Green STEAM education. This positioning, in turn, contributes significantly to a future



characterized by heightened technological advancements and enriched insights in pivotal areas such as Sustainable Innovation, Climate Change Mitigation, Environmental Awareness, Resilient Communities, and Global Impact.

## CONCLUSIONS

STEAM education in Slovenia is undeniably charting a positive trajectory, bolstered by a resolute commitment to equipping students with the essential skills, comprehensive knowledge, and adaptable mindset crucial for excelling in a technology-driven society. At the heart of this educational evolution lies a robust emphasis on experiential learning, interweaving disciplines in a manner that ignites holistic understanding. By nurturing an environment where hands-on exploration flourishes, Slovenia is cultivating a fertile ground for students to grasp complex concepts through tangible engagement.

Intriguingly, the educational landscape in Slovenia thrives on interdisciplinary approaches, transcending the conventional boundaries of courses. This methodology not only mirrors the real-world dynamics but also cultivates in students the prowess to connect ideas across seemingly disparate domains. As a result, learners are equipped to tackle multifaceted challenges by approaching them from myriad angles, fostering an innovative mindset that holds tremendous potential.

Moreover, Slovenia's strategic partnerships with industries amplify the real-world applicability of education. By bridging academia and industry, students gain access to practical insights, cutting-edge developments, and the opportunity to work on projects that mirror actual professional scenarios. This symbiotic relationship enhances the quality of education while also preparing students to make meaningful contributions as they transition into the workforce.

In essence, Slovenia's dynamic approach to STEAM education is a strategic investment that doesn't merely create proficient graduates; it shapes proactive problem solvers and forward-thinking innovators. This transformative education isn't confined to national borders—it reverberates globally. The solutions incubated within Slovenian classrooms hold the potential to address not only local challenges but also the broader spectrum of global issues, from environmental sustainability and resource management to health advancements and technological breakthroughs. In this way, Slovenia is carving a path towards systematically introducing sustainability and green transition in education that extends far beyond the classroom, shaping a future where knowledge and ingenuity act as driving forces for progress.



## REFERENCES

- (1) Taštanoska, T. *The Education System in the Republic of Slovenia 2018/2019*; 2019.
- (2) Bahovec. Kurikulum Za Vrtce. **1999**, 54.
- (3) mag. Suzana Antič, Vrtec Trnovo Ljubljana dr. Sanja Berčnik, Univerza v Ljubljani, Pedagoška fakulteta mag. Janja Cotič Pajntar, Zavod Republike Slovenije za šolstvo dr. Ljubica Marjanovič Umek, Univerza v Ljubljani, Filozofska fakulteta dr. Maja Hmelak, Z. R. S. za šolstvo; Jezikovni. *Izhodišča Za Prenovo Kurikuluma Za Vrtce*; Pajntar, mag. J. C., Umek, dr. L. M., Zore, N., Eds.; 2022.
- (4) Načrt za okrevanje in odpornost (NOO) <https://www.gov.si/zbirke/projekti-in-programi/nacrt-za-okrevanje-in-odpornost>.
- (5) Compulsory Education - Basic School. **2020**.
- (6) Secondary Education in the Republic. **2014**. <https://doi.org/10.5040/9781472541499.ch-008>.
- (7) Izhodišča Za Prenovo Učnih Načrtov v Osnovni Šoli in Gimnaziji. **2022**.
- (8) Tertiary Education in the Republic of Slovenia. **2022**.
- (9) EU STEM Coalition <https://www.stemcoalition.eu/>.
- (10) University of Ljubljana <https://www.uni-lj.si/eng/>.
- (11) European Commission. A Green Deal Industrial Plan for the Net-Zero Age. **2023**.
- (12) Materials for Energy Storage and Conversion - Curriculum <https://mesc-plus.eu/the-master/curriculum>.
- (13) Study programme - Advanced Power Systems <https://old.fe.uni-lj.si/mma/Advanced-Power-Systems-brochure/2019060414394995/>.
- (14) Study programme curriculum Environmental protection [https://www.uni-lj.si/mma/predmetnik\\_varstvo\\_okolja\\_ang/2023062010061309/?m=1687248373](https://www.uni-lj.si/mma/predmetnik_varstvo_okolja_ang/2023062010061309/?m=1687248373).
- (15) Biotechnical Faculty - Study Programmes <https://www.bf.uni-lj.si/en/study/study-programmes/>.
- (16) Study programme curriculum Biosciences [https://www.uni-lj.si/mma/predmetnik\\_bioznanosti\\_ang/2023062007350484/?m=1687239304](https://www.uni-lj.si/mma/predmetnik_bioznanosti_ang/2023062007350484/?m=1687239304).
- (17) University of Ljubljana research infrastructure [https://www.uni-lj.si/mma/ul\\_research\\_infrastructure/2023032810312058/?m=1679992280](https://www.uni-lj.si/mma/ul_research_infrastructure/2023032810312058/?m=1679992280).
- (18) Report on EU tenders and applications for EU projects in 2021 and the current status of EU projects at UL [https://www.uni-lj.si/mma/porocilo\\_usrd\\_za\\_let\\_2021\\_koncno/2022111415144600/?m=1668435286](https://www.uni-lj.si/mma/porocilo_usrd_za_let_2021_koncno/2022111415144600/?m=1668435286).
- (19) Education for Sustainable Development <https://www.acs.si/en/projects/national/education-for-sustainable-development/>.



Co-funded by  
the European Union



- (20) Lifelong learning of adults for sustainable development and digital breakthrough  
<https://www.acs.si/en/projects/national/lifelong-learning-of-adults-for-sustainable-development-and-digital-breakthrough-2021-2023/>.
- (21) *Measuring Innovation in Education*; Educational Research and Innovation; OECD, 2014.  
<https://doi.org/10.1787/9789264215696-en>.
- (22) Education and Training Monitor 2020 - Slovenia <https://op.europa.eu/webpub/eac/education-and-training-monitor-2020/countries/slovenia.html>.



# THE STATE OF THE ART ANALYZE ABOUT STEM EDUCATION PRACTICES IN GREECE

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## 1 STEM education

The rapid changes in scientific, social and political culture point to reorientations of the curricula as well as the development of new career opportunities, mainly related with Sciences, Technology, Engineering, and Mathematics (STEM). The current view for STEM education, the so-called integrated STEM education, gets above the notion of high-quality education in STEM fields.

Integrated STEM education concerns the incorporation of real-authentic world problems in the teaching process. This approach involves Engineering (E) not only as a separate discipline, but also mainly as a way of thinking and solving problems by considering the restrictions of the real world. Integrated STEM education aims at the development of cognitive skills as well as the development of the 21<sup>st</sup> century competences (critical thinking, creativity, collaboration, communication). Integrated STEM approaches are transdisciplinary and interdisciplinary and follow student-centered constructivist instructional models, such as inquiry-based and project-based learning.

Recently, STEM is expanding to involve fields such as social sciences or culture. Terms like STEMAC or STEAM appear and concern fields of natural sciences, technology, sciences of engineering, arts, and mathematics. It is noteworthy that Arts mainly refer to the creative way of thinking Arts imply. STEM also promotes teaching and learning in inclusive educational environments. In contrast to more traditional instructional models, educators using STEAM apply approaches where students reinforce inquiry skills. Experiments, learning technologies, creation of mechanical constructions, cultivation of mathematical thinking and training of basic principles regarding programming and algorithmic thinking promote the philosophy of STE(A)M. These processes are based on inquiry adopting John Dewey's principle that highlights curiosity as a starting point in educational settings (Savery, 2006). Specifically, students inquire when they go through all stages of a scientific research: to ask a question, to develop a hypothesis, plan how to test that hypothesis, collect data, analyze the results and share them with their classmates (Pedaste et al. 2015). Inquiry-based model seems ideal for science education because it turns teaching into practice. Students learn in an active way how to formulate questions and answers through experimentation, while the teacher has both a mediating role and an instructor role. STE(A)M is based on problem learning and solving aimed at making students "good problem solvers" in the real world. Project-based learning is a form of situated learning based on constructivist theory that students acquire knowledge by actively building understanding, co-working and sharing ideas (Krajcik and Blumenfeld,





2006). Some areas of this method are group work, listening, respecting the opinions and presentation skills of others (Wood, 2003). Research shows that problem-based learning provides specific opportunities for "developing flexible understanding and lifelong learning skills" (Hmelo-Silver, 2004) such as posing a problem through different cognitive areas while a key element is the student-centered approach where the students themselves are responsible for the solution of the problem resulting in having stronger motives and acting in a cooperative way (Savery, 2006).

One dimension of STEM education is to solve environmental problems (Widya et al., 2019). This is towards the direction of the so-called recently "Green STEM" education, "the intersection between STEM and Environmental Education" (Garcia-Piqueras, & Ruiz-Gallardo, 2021). Yean and Abdul Rahim note that "Sustainable Development and sustainability, lies at the heart of Green STEM" (2021). Green or Greening STEM education concerns the design and development of environmentally centered programs that add value to students lives and well-being and contribute to the school community (social world). As mentioned above, a third synonymous term that is used to describe Greening or Green STEM education is Education for Sustainable Development.

Lately, various organizations are interested in Green STEM education. The National Environmental Education Foundation (NEEF) in USA, claims that by "incorporating elements of place-based learning, three-dimensional learning, project-based learning, and community-based learning, the Greening STEM approach increases students' academic achievement, strengthens their ties to their community, and encourages a deeper appreciation for the environment" (<https://www.neefusa.org/what-we-do/k-12-education/greening-stem-hub/greening-stem-approach>). In the same line, the National Oceanic and Atmospheric Administration (NOAA, USA) supports that through Green STEM education, students respond to "challenges in the natural environment" (<https://www.noaa.gov/education/stories/environmental-education-shows-what-it-means-to-do-green-stem>).

In the following sections, we provide information about STEM education in Greece and recommendations for certain actions.



## 2 The state of STEM education in Greece

### 2.1 STEM education in elementary and secondary education

#### 2.1.1 Skills Labs

STEM education in Greece is met at all levels of education, starting from preschool to tertiary education. In elementary and secondary education, STEM education is involved into a discipline called “Skills Labs” which is taught in preschool, elementary, and secondary education. Following this approach, STEM education focusses on the development of scientific attitudes and values through educational activities in terms of constructivist learning approaches. The “Skills Labs” also called “skills development laboratories” (Platform 21+: Ergastiria Dexiotiton” / 21st Century Skills Labs) consist of four axes, coming from the Global Sustainable Development Indicators (environment, well-being, social empathy and responsibility, creative thinking and initiative) (<https://elearning.iep.edu.gr/study/course/index.php?categoryid=44>, <http://iep.edu.gr/el/psifiako-apothetirio/skill-labs/1008-stem-steam>).

The fourth axes “creative thinking and initiative” of the Skills Labs proposes targeted STEM skills development, which are grouped as follows:

C) Technology, engineering, and science skills.

C1. Technology skills (Skills for creating and sharing digital creations, Skills for analyzing and producing content in printed and electronic media, Skills for interdisciplinary and cross-curricular use of new technology).

C2. Media Management Skills (Information Literacy, Digital Literacy, Technology Literacy, Media Literacy, Internet Safety).

C3. Robotics (Modeling and simulation skills, Scientific/computational thinking).

Skills Labs are innovative educational activities, which consist of pilot implementations of topics that promote active participation, problem-solving skills and new ways of working and thinking on global issues. Skills Labs address students from kindergarten to high school. It includes a “Platform 21+: “Ergastiria Dexiotiton” - an open-source learning environment for teachers to collaborate and exchange good practices. The aim is to strengthen cognitive, affective, and psychomotor skills (soft skills, life skills



and digital and science skills that promote democracy, equity, social cohesion, inclusion, active citizenship, volunteering, global local interconnectedness, problem solving and respect for diversity) within an inquiry learning framework based on the structure of open, daily life study programs and processes.

The Skills Labs pilot implementation was conducted during the school year of 2020-2021 and the main sample was consisted of 58 kindergartens, 58 elementary schools, 58 high schools and the mainstream and model schools in Greece. The inclusion criteria for the schools concerned two basic factors: the representative geographical distribution of each school unit, and the capacity which is referring to the number of students and teachers.

Seven training periods/cycles of the "Training of teachers in skills through labs" program have been implemented through the "Training Program" directed by the Institute of Education Policy (IEP), on a specifically designed platform which is addressed to primary and secondary teachers.

The educational material and activities were developed in collaboration with several stakeholders, including local government bodies for civil rights (Secretary for the Family and Equality), NGOs, intergovernmental organizations (High Commission for Refugees, UNICEF) and university research institutes and centers, private sector, research and educational bodies and local authorities. More than 2,500 teachers in 217 schools have been trained in designing and implementing classroom action plans, teaching and learning activities, 21<sup>st</sup> Century Skills and inquiry and participatory learning methods.

Regarding the special content of the Skills Labs, descriptive evaluations were designed based on the program timeline and the development of students' skills through synchronous and asynchronous remote teacher training.

The Skills Labs were awarded by the Global Citizen Education Network (GENE) for 2020/21 research and action in education (Quality and Good Practice in Global Education across Europe) (<https://static1.squarespace.com/static/5f6decace4ff425352eddb4a/t/61b739351506e6647a587555/1639397744394/2021GEAwardPublication.pdf>)

The digital repository regarding the STEM – Robotics thematic consists of two axes: training programs and organization programs.

The training programs include the following topics:

- "The little explorers" (Kindergarten and 1<sup>st</sup> Primary)



- "STEM and the Earth turns" (Kindergarten)
- "Phenomena in the Nanocosm" (5<sup>th</sup>, 6<sup>th</sup> Primary)
- "Electric current you are "accused" of..." (5<sup>th</sup>, 6<sup>th</sup> Primary)
- "First time godparents" (5<sup>th</sup>, 6<sup>th</sup> Primary)
- "Robots at the service of recycling" (Kindergarten, 1<sup>st</sup>, 2<sup>nd</sup> Primary)
- "The power of the lever and the example of the catapult. The role of leverage in the human-made environment" (5<sup>th</sup> Primary)
- "Transformations of geometric shapes and solids" (5<sup>th</sup> Primary)
- "We create buildings friendly to the environment and people" (5<sup>th</sup>, 6<sup>th</sup> Primary)
- "Seasons and Climate" (5<sup>th</sup> Primary)
- "Stop motion animation: When pictures move" (4<sup>th</sup>, 5<sup>th</sup>, 6<sup>th</sup> Primary)
- "Digital literacy: Creative and safe internet" (5<sup>th</sup>, 6<sup>th</sup> Primary, 1<sup>st</sup> high school)
- "Digital Intelligence: Adapting to the modern digital world" (5<sup>th</sup>, 6<sup>th</sup> Primary, 1<sup>st</sup> high school)
- "We're designing a robot" (4<sup>th</sup>, 5<sup>th</sup>, 6<sup>th</sup> Primary)
- "I'm becoming a creator of my schoolyard!" (all grades of the Primary School)
- "My pencil case" (introduction to 3D design and printing)" (1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> high school)
- "Promoting learning through art" (1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> high school)
- "Creating a story/game using Scratch" (2<sup>nd</sup> year high school)
- "Robotics with Arduino" (2<sup>nd</sup>, 3<sup>rd</sup> high school)
- "Greenhouses, combining nature with technology" (1<sup>st</sup>, 2<sup>nd</sup> grade high school)
- "3D printing with the help of tinkercad" (2<sup>nd</sup> grade high school)
- "The world of interior architecture and decoration with Homestyler" (2<sup>nd</sup>, 3<sup>rd</sup> grade high school)
- "The earth is not flat (everything flows) - Newtonian mechanics" (2<sup>nd</sup> grade high school)
- "It can't do anything by itself - So let's give life to our little robot (using Lego Mindstorms NXT). Introduction to the profession of programmer" (2<sup>nd</sup> grade high school)
- "Artificial Intelligence" (1<sup>st</sup>, 2<sup>nd</sup> high school)
- "I'm learning to learn: I'm talking to myself... and I'm right!" (1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> high school)
- "Designing the smart school" (1<sup>st</sup> and 2<sup>nd</sup> grade high school)



- "The Hidden Message Game" (1<sup>st</sup> and 2<sup>nd</sup> year high school).

The organization programs include the following topics:

- "Little Meteorologists" (Kindergarten and 1<sup>st</sup>, 2<sup>nd</sup>, Primary)
- "European School Radio, The First Student Radio" (Kindergarten, Primary and High School)
- "ELEPHYS - Illustrated Physics Dictionary for School" (5<sup>th</sup>, 6<sup>th</sup> Primary and 1<sup>st</sup> and 2<sup>nd</sup> high school)
- "STE(A)M and Educational Robotics through the Water cycle and Hydrodynamics" (Kindergarten and 1<sup>st</sup> Primary)
- "Heroes of the World" (3<sup>rd</sup>, 4<sup>th</sup>, 5<sup>th</sup> Primary)
- "TV Literacy Activities" (3<sup>rd</sup> – 6<sup>th</sup> Primary and 1<sup>st</sup> – 3<sup>rd</sup> High School)
- "Materials for a Sustainable Future" (1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> High School)
- "Study Program for STEAM" (2<sup>nd</sup> – 6<sup>th</sup> Primary, 1<sup>st</sup> – 3<sup>rd</sup> High School)
- "Digital Humanities" (1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> High School)
- "The School Class Meets the Scientist" (4<sup>th</sup> – 6<sup>th</sup> Primary)
- "Tomorrow's Scientists and Engineers" (6<sup>th</sup> Primary and 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> High School)
- "First Lego League Jr" (1<sup>st</sup> – 4<sup>th</sup> Primary)
- "Safe Internet Use Guides" (1<sup>st</sup> – 6<sup>th</sup> Primary and 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> High School)
- "Schools Study Earthquakes – The SNAC Platform" (1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> High School)
- "EnvStories Platform (Kindergarten, 1st - 6th Primary)
- "Educational Robotics in Kindergarten Activity Labs" (Kindergarten)
- "Discovering STEAM" (Kindergarten, 1<sup>st</sup> – 6<sup>th</sup> Primary and 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> High School)
- "Educational Robotics in Elementary School Activity Labs" (1<sup>st</sup> – 6<sup>th</sup> Primary)
- "Educational Robotics in High School Activity Labs" (1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> High School)
- "'The lesson... game!' An Educational Guide to Designing Tabletop and Digital Narrative Games" (1<sup>st</sup> – 6<sup>th</sup> Primary and 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> High School)
- "Teaching spatial thinking" (1<sup>st</sup> – 6<sup>th</sup> Primary and 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> High School)



- "Robotics and STEAM FLL Program" (Kindergarten, 1<sup>st</sup> – 6<sup>th</sup> Primary and 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> High School)
- "Young researchers interpret their environment with Web GIS technology " (1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> High School)
- "SKILLS LABS implemented even in school units with rudimentary equipment" (Kindergarten, Primary, High School)
- "App Your School" (5<sup>th</sup>, 6<sup>th</sup> Primary, 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> High School)
- "STEAMulate Your School" (5<sup>th</sup>, 6<sup>th</sup> Primary, 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> High School)
- "Empowering Girls in Steam Education through Robotics and Programming" (Primary, High School)
- "Chess and Imagination" (Kindergarten and 1<sup>st</sup>, 2<sup>nd</sup> Primary)
- "Chess, a game of strategy and Math, a game for everyone!" (4<sup>th</sup>, 5<sup>th</sup>, 6<sup>th</sup> Primary)
- "Protecting our forests" (5<sup>th</sup> Primary)
- "EnvStories Platform" (Kindergarten, Primary Education)
- "Waste Not- Composting, the recycling of nature...." (Primary).

#### *2.1.1.1 Evaluation of the application of the Skills Labs*

The Institute for Educational Policy (IEP) announced the results of the assessment of the first implementation of the Skills Labs. The research was carried out through the electronic completion of a questionnaire which was distributed through the infrastructure of the Panhellenic School Network and was carried out in the period 15-30 June 2022 with the participation of 11039 schools (5156 kindergartens, 4166 primary schools, and 1717 high schools). The results indicated that the whole school community (teachers and students) welcomed the implementation of the Skills Labs both as a whole context (highlighting the added value) and as individual parts (the range of the topics, methodology, portfolio, training, diffusion).

Regarding the evaluation of the content and the instructional methodology, the results showed that teachers evaluated positively the scope of the thematic units and their potential to cultivate the targeted skills and that the existing thematic units cover all the topics that contribute to the cultivation of skills, with the most important tool that contributes to the differentiation of the instructional



methodology being the group-collaborative method and the laboratory approach, with constructions, presentations, games and theatrical events.

An important factor of the assessment regarding the effectiveness of the implementation is the response of the students to the content and the new methodology as well as the perceived contribution a) in the holistic and multifaceted development of students, b) in strengthening knowledge, attitudes, values and skills c) in improving the participation of students in the teaching process. The teachers felt that the most important contribution was that the students became more active and devoted personal time to investigation, preparation and constructions they had decided in the Skills Labs.

Regarding the educational process, the teachers recognize the importance and contribution of the educational program prepared by the IEP, but the implementation in the teaching practice is characterized by a moderate to greater degree of difficulty. The most important problems for the implementation are found mainly in the long duration needed to implement the labs as well as the equipment and the logistical infrastructure of the school units.

To a large extent, teachers agree that the Skills Labs were a key parameter of the school's operation, mainly with the positive response of the students to the content and the new methodology that enhance the cultivation of soft skills, life skills and digital and science skills, combined with the formation of a modern framework of educational programs.

The questions of the empirical study and their corresponding results are presented in short as follows.

**Q1: Do the thematic sections cover all contributing topics in skill building?**

The percentage of teachers who thought that the existing thematic sections cover all topics that contribute to skills cultivation is 75.3% (satisfactory 63.6%, excellent 11.7%), while the percentage placed negatively is 5.1% (not at all 0.6%, a little 4.6%).

**Q2: Did the implementation of the Skills Labs contribute to differentiation of the instructional methodology (introduction and/or extension of application of experiential, laboratory and exploratory methodology?)**





The percentage that positively valued their contribution to the Skills Labs in the differentiation of the methodology was 58% (excellent 6%, satisfactory 52%), while the percentage of negative evaluation was 15% (not at all 4%, a little 11%).

**Q3: What were the elements that helped to differentiate the instructional methodology?**

The answers showed that most important element that contributes to differentiation is the collaborative method (85.9%). Workshops or presentations, games, and theatrical follow with 69%. The instructional methods "Research - action" and "project" take the third place (52%). In comparison, the options that collected the higher negative percentages were "interviews - getting to know professionals and important personalities" with a rate of 68.7%, "the preparation and implementation of research plans" with a percentage of 75.9% and the "flipped class " with a rate of 85.1%

**Q4: Did the training of teachers on Skills Labs play a role in the implementation of the Skills Labs at school?**

The contribution of training was rated very positively. The percentage of responses with a positive view is significantly higher 51.2% (excellent 9%, satisfactory 42%) of the percentage of negative responses 22% (not at all 6%, a little 16%).

**Q5: Were there any intra-school actions implemented regarding trainings for the implementation of the Skills Labs? If YES, who were they rapporteurs?**

Regarding in-school trainings, schoolteachers got 36%, followed by the Coordinators of Educational Projects with a percentage of 19%, and teachers from other, with a rate of 12%.

**Q6: Was there a common orientation formed for the implementation of workshops in all classes?**

The largest percentage of teachers gave a positive answer (83%), while the rest considered that there was no common orientation formed.

**Q7: If YES, did the formation of common orientation (Action Plan) of the school unit contributed to promoting the implementation of Skills Labs?**

The 87% of the responses recognize the contribution (excellent 21%, satisfactory 66%), while the negative position received a rate of 2.6% (not at all 0.5%, 2.1%)



**Q8: For the disseminating of the action plan, we are planning or have implemented:**

The exhibition of students' projects is placed in the first place with a percentage of 57.3%. In the second-place projects are posted on the School's website, with a rate of 43.8%, while end of the school year events are placed in third place.

**Q9: Did the portfolio as a methodological tool for evaluating the student function as a tool for promotion and feedback of the teaching process?**

The percentage of positive responses 47.8% (excellent 7.6%, Satisfactory 40.2%) recorded a large difference from the negative response rate of 21.5%.

**Q10: To what extent did your students respond to the Skills Labs?**

The percentage of positive responses was 76.6% (high 64.8%, very high 11.7%) with a significant difference from the percentage of opinions that were placed negatively (4.4%) (not at all 0.4%, a little 4.0%).

**Q11: Did the existing sub-topics per class correspond to students' interests?**

The percentage who answered positively was 73% (satisfactory 59.9%, excellent 12.1%). The corresponding percentage of responses that rated negatively the responsiveness of the sub-themes to the students' interests was 6.1% (a little 5.2%, not at all 0.9%).

**Q12: Do you consider that the Skill Workshops contributed to promoting the holistic and multifaceted development of students of your class(es)?**

Teachers answer positively in 54% (satisfactory 46.4%, excellent 7.6%), while the negative assessment receives a rate of 14.1% (a little 11.3%, not at all 2.8%).

**Q13: Do you think that the Skills Labs contributed to the strengthening of students' knowledge, attitudes, values and skills?**

Teachers respond positively to a rate of 62.7% (satisfactory 52.9%, excellent 9.8%), while the negative assessment receives a rate of 10.2 % (a little 8.6%, not at all 1.6%).

**Q14: Did you observe an improvement in the participation of your students in the teaching process?**



The teachers respond positively at a rate of 61.1% (satisfactory 51.9%, excellent 9.2%), while the negative evaluation receives a percentage of 12.4 % (a little 9.4%, not at all 3.0%).

**Q15: In which field was the improvement of students' behavior observed?**

Teachers reported that the most important contribution is that the students were more active in their group, with a rate of 80.8%. In the second place was recorded the answer that the students dedicated their personal time in research, preparation and constructions they had planned for the Skills Labs (47.4%).

**Q16: What was the level of difficulty in implementing the Skills Labs?**

The percentage of responses that stated that the implementation was characterized by some degree of ease was 12.2% (easy 10.4%, very easy 1.8%), while respectively the percentage of responses that stated that the implementation was characterized by some degree of difficulty was 32.9% (difficult 27.0%, very difficult 5.9%).

**Q17: What were the main problems in the implementation of the Skills Labs?**

The percentage of teachers who testified that they did not encounter any problems was only 3% with the remaining 97% stating that they experienced problems. According to the answers, as the most important problem is recorded the length of time that the application of the Skills Labs is needed in every class (85.8%). In second place the logistic infrastructure of the schools is placed with a rate of 68.6%, while teacher training is also considered an important problem by 33.3% of the teachers. It should be noted that the answers regarding the declaration of training as a problem contradicts the large number of those trained in the Workshops and their satisfaction that came from the training as recorded in relevant questions.

**Q18: How do you evaluate the added value of the Skills Labs at the level of the educational community?**

The results showed a high degree of positive evaluation, as the difference between positive responses (high, very large) and negative ones (not at all, small) is significant. Specifically, the positive attitude received a percentage of 36.8% (very high 5.3%, high 31.5%) while the negative is 16.9% (not at all 2.4%, small 14.5%). If at the rate that describes the positive attitude, we add the percentage of those that chose “moderate” (not negative attitude), then the total percentage of positive evaluation



(moderate, large, very large) reaches 83%, a rating that shows the great acceptance and recognition the Skills Labs have in the educational process.

In conclusion, based on the above results, the Skills Labs are a key parameter in the operation of the corresponding schools and were well accepted by the educational community, which recognized the added value they offer to the organizational structure of the learning process. The students' response to the content and the new methodology was positive towards the cultivation of soft skills, life skills, technology and science skills, combined with the formation of a modern framework of educational programs.

### 2.1.2 The “Technology” lesson in junior high school

STEM education has also been integrated into the Greek education system as part of the “Technology” lesson taught in all three classes in the junior high school.

The fourth industrial revolution is characterized by the "integration" of technology with natural and health sciences, engineering, "computing, computer engineering, information science - information technology", as well as of arts and humanities so that students are equipped with 21<sup>st</sup> century skills and acquire “STEM skills”.

"STEM skills" include the ability to solve "ill-defined problems", analytical and logical thinking, computational thinking, interdisciplinary approach, creating artifacts through the engineering design process and technical skills. All the above require a broad and holistic knowledge of the cognitive areas that appear in the acronym of STEM (Science, Technology, Engineering, Mathematics), arts and computer science.

The curriculum of the “Technology” lesson in the Greek junior high school takes into account the above mentioned, which are also combined with:

- a) responsible research and innovation
- b) the "holistic" design for learning
- c) technology as a process/activity, as well as technology as a product through its connection with sciences and arts, mathematics, engineering, computational science, computational thinking and interdisciplinary/ holistic/integrated STEAM education.



All the above is leveraged in "integrated STEAM education" when artifacts that are compatible with natural laws are created to solve a real-world, usually ill-defined, problem, while math and science concepts are taught during artifact construction. "Integrated STEAM education" is linked to technology through the application of pedagogical approaches based on the engineering design process and inquiry-based model, in order to teach concepts, develop skills and the way scientists and engineers think.

The "Technology" lesson follows the three approaches:

1. The teaching approach: Students engage in interactive inquiry-based learning activities related to real problems defined by the holistic approach of "STEAM education", the design process of engineering and the creation of artefacts through the "STEAM content approach".
2. The approach of inclusion and responsible research and innovation: Through students' involvement in inquiry-based learning activities, they will understand the dimensions of responsible research and will accept diversity, while the solutions proposed will be compatible with the particularities of the local society. Students will also understand the impact of technology on their professional development through the skills acquired, while developing beliefs and attitudes on the value of technology. Finally, students will understand the role of their personal responsibility at a personal, local and national/European level in the development of technological products.
3. Social and economic approach: Students will understand the contribution of technology to the development and implementation of artefacts that serve the social and economic development of the local society and their country.

Throughout the lesson, the problems and activities that will be proposed will often not be clearly defined from the beginning, but the teacher should, in collaboration with the students, define the problem before solving it so that the students can engage with the engineering design process and the inquiry-based model and be driven to 'technological solutions'.



### 2.1.3 Summary

STEM education in the formal Hellenic primary and secondary education has been introduced through two ways:

1. As a part of the “Skills Labs” discipline (kindergarten, primary, and high school)
2. As a part of the “Technology” lesson (junior high school).

The integrated STEM approach is proposed.

The results from an empirical study concerning the “Skills Labs” are positive, especially for the development of digital and science skills, soft skills, life skills, as well as for the instructional models followed. The main constraints reported are:

- The long duration needed to implement the STEM educational scenarios.
- The necessary infrastructure at schools.

The teachers training programs as well as the scenarios enacted, as presented above, indicate that many scenarios, but not all of them, were designed by following the integrated STEM approach.

## 2.2 STEM education in higher education

In tertiary education, STEM education appears as undergraduate and postgraduate courses, master’s programs, doctoral topics, as well as further training seminars (e-learning seminars). Since Universities design their own curricula, STEM courses appear in various Departments and their content varies in nature and objectives.

### 2.2.1 University Undergraduate Curricula at Departments of Education

Education faculties and departments play an important role in STEM education since they train future teachers, those who will apply the STEM approach in everyday school practice. In Greece, University departments’ undergraduate curricula are determined independently by the corresponding departments.

It is noteworthy that only one department of Preschool Education offers a course relevant to STEM.



1. Department of Early Childhood Education, University of Western Macedonia. “Robotics and STEAM education”.

The main course contents refer to:

- Educational Robotics
- STEAM Training
- Realistic problems and connection to the real world
- Added value of STEAM problems
- Sensors and Robotic structures
- Physical interfaces.

On the other hand, the departments of Primary Education offer a number of related courses. There are courses whose main focus lay on STEM, whereas there are others that partly refer to STEM. The STEM related courses offered by departments of Primary Education follow.

2. Department of Primary Education, University of Ioannina: “STEM Education”

Students are expected to:

- Understand and analyze the principles of the STE[A]M approach.
- Design educational scenarios within the STE[A]M approach.
- Evaluate educational scenarios and STE[A]M applications.
- Create applications within the STE[A]M educational scenarios.

3. Department of Primary Education, University of Ioannina: “Research Approaches to STEM Education”

Students should be in position to:

- recognize the importance of interdisciplinary approaches





- think and decide by adopting and applying principles of scientific methods
- judge and utilize research results in the wider area of STEM subjects
- process and analyze primary and secondary literature and empirical research data.

4. Department of Primary Education, University of Ioannina: “Use of Information & Communication Technologies in Educational Research”.

The course partly refers to STEM since it requires students to:

- know use utilize STEM theoretical assumptions and teaching practices in education and be able to assist research in relevant projects.

5. Department of Primary Education, Aristotle University of Thessaloniki: “Science Education”.

The course partly refers to STEM since it requires students to:

- be able to formulate and apply the main axes of STEM education
- study the Basic Principles of STEM Education and its relation to Science Education in Elementary School.

6. Department of Primary Education, Aristotle University of Thessaloniki: “Gender and Play”.

The course partly refers to STEM since it presents issues such as:

- "Girly" games seriously harm the development of interest for the scientific fields of STEM
- “Pink” Lego construction toys and other specially designed STEM toys 'for girls' - Is it good for girls?

7. Department of Primary Education, University of Crete: “Digital Technologies in Interdisciplinary STEM Education”.



8. Department of Primary Education, University of Crete: “Science, Technology, Engineering and Mathematics (STEM) in Education”.

9. Department of Primary Education, University of Western Macedonia: “Development of teaching scenarios for STEAM using educational robotics”.

Students should be able to develop complex interdisciplinary teaching scenarios using robotics and other embodied learning environments. Emphasis is placed in the teaching of STEAM concepts so that students gain a holistic understanding of the provided teaching tools.

### 2.2.2 Master’s programs

Regarding master’s programs there are four programs offered by Greek Universities. These are:

1. Department of Primary Education, University of Athens: “STEM education and Educational Robotics Systems”.

The program aims to train specialized scientists, researchers, trainers, teachers and executives of formal and non-formal education, so that they can contribute to the development of scientific research, the promotion of scientific knowledge and the application of appropriate practices in the fields of Mathematics Education, Natural Sciences, Technology and Engineering.

2. Informatics and Telecommunications Department, University of Thessaly and School of Pedagogical and Technological Education – ASPAITE: “Educational Applications with STEM Epistemology”.

The curriculum pursues epistemological inquiry and examination of topics, with a focus on educational, laboratory and learning/teaching sequences in STEM subjects. The epistemology of STEM is based on interdisciplinarity and inter-disciplinarity or cross-disciplinarity, with a basic orientation to solving complex problems of real situations, utilizing tools and interactive methodologies from various scientific fields. With the adoption of interdisciplinarity and interdisciplinarity as epistemological content of STEM, students have the possibility to explore and apply computational approaches to the subjects of STEM.



3. Department of Production and Management Engineering, International University of Greece: “Robotics, STEAM and New Technologies in Education”.

The purpose of the program is to create highly trained scientists by providing specialized knowledge in educational robotics, STEAM fields and new technologies in education, which can be used both in the educational process and in the development of new educational methodologies and techniques. Graduates acquire the required skills for a successful career as high-ranking executives both in the private sector (educational institutions and structures, companies providing services in automatic control systems, in the development of educational materials, management departments of large companies, etc.) and in the public sector (public organizations, educational institutions, research centers, etc.).

4. School of Pedagogical and Technological Education – ASPAITE: “Master of Science in Science, Technology, Engineering and Mathematics” (discontinued).

This is a program through which the in-depth epistemological and scientific investigation and examination of subjects is sought, with a focus on the laboratory, learning and educational learning and teaching sequences for education, in relation to the cognitive subjects of STEM, and the modern pedagogical theories and educational technologies. The purpose of the PMS is to provide high-level training in Computing Science for education and Teaching in STEM subjects. Furthermore, it expects to contribute to the promotion of research and the creation of new innovative knowledge and skills as well as the professional development of teachers.

### 2.2.3 Master and PhD theses on STEM

In order to find Master theses and PhD dissertations related to STEM conducted in Greek Universities, a survey took place in the OpenArchives, a portal that provides a single point of access to Greek scientific content (OpenArchives.gr). Content providers of OpenArchives are libraries, archives, museums, academic and research institutions.

The inclusion criteria were “STEM” and “Education”, limiting the search from 2018 to today.

A total of 37 Master theses were retrieved. Their content is briefly presented in chronological order in tables 2.2.3.1 – 2.2.3.6



Table 2.2.3.1 STEM relevant Master theses, Year 2018

Title	Short Abstract
<p>Development of Environmental Education training material to study particulate matter PM10 and PM2.5. Construction and operation of a low-cost measurement and data-logging station</p>	<p>Particulate matter is considered to be one of the most harmful pollutants to <b>human health</b>. At the same time, the pollutants also affect other members of the ecosystems. This study deals with the design and implementation of an educational environmental project, in which students discover important aspects of the problem of particulate matter of diameter between 2.5µm and 10µm through the "construction" of a pollutant measuring instrument. The Arduino Uno development board was used as a basis for the construction of the measurement tool, while the SDS011 was used as the particle sensor and the AM2302 (DHT22) sensor was used for measuring atmospheric temperature and relative humidity. The measurements are recorded on an SD card and are displayed at the same time on an LCD screen. The project was implemented at the second grade of the EPA.L. (Vocational High School), of Chrysoupoli (Kavala). The data which was collected suggests that the students of the <b>second grade of High School</b> are able, with the help of a specific guidance, to build the measuring tool for the aforementioned pollutants, operating in a cooperative environment and through this "Constructionistic" process to investigate cognitive aspects concerning the identifying and measuring the studied pollutants, in a very pleasant way for of the students.</p>



<p>Augmented reality and education: Exploring the emotional outcomes in primary school students in the context of teaching about the Solar System</p>	<p>Teaching STEM education is a complex issue, as students often find it difficult to successfully approach and understand their content. Reforming STEM education and integrating technology into it is one of the most important directions that modern education could follow. Educational Augmented Reality applications create the right conditions for students to effectively approach and interact with STEM sciences and activate experiences and skills that otherwise would not be feasible. In this study an educational intervention is presented that was conducted aiming approaching and teaching the science of <b>Astronomy</b> in 39 <b>elementary school</b> students. Within the framework of this intervention a mobile AR educational application was used. The main objective was to explore and evaluate emotional outcomes of students through a self-referential scale. The results showed that 1) the emotional mood of both the experimental group and the control group was improved after the intervention and that 2) the emotional mood of experimental group's students was more positive than that of the control group.</p>
<p>Contribution of the online platform ILS (Inquiry Learning Spaces) to the teaching of photosynthesis through inquiry.</p>	<p>Inquiry-based educational approaches lead, mostly, in positive student results. Although these approaches can vary, one of the best is the application of computer-based learning environments. Their superiority is widely accepted due to the fact that they display many advantages compared to the traditional means and, additionally, they have been shown to further improve the learning outcomes, generated by the application of inquiry methods. In the present study,</p>



	<p>we selected the Go-Lab program (Global Online Science Labs for Inquiry Learning at School), a European collaborative project, funded by the European Commission, as well as other funding agencies. Go-Lab is dedicated to the promotion and the support of STEM education, which in turn is based on inquiry-based educational approaches. The present study evaluates the contribution of an educational electronic platform (Go-Lab) in <b>photosynthesis</b> teaching, through inquiry-based educational methods. The study sample is consisted of 92 <b>second-grade high-school students</b>, and the educational intervention is comprised of three teaching hours. The analysis proved that after the intervention, students (regardless of their gender) displayed a statistically significant improved understanding of the subject.</p>
Construction and Teaching Use of the Hydrobot by Future Teachers, in the Context of a STEM Education Aiming at Scientific Literacy	<p>Hydrobot Program is a STEM program brought to Greece by the Eugenides Foundation and is the Greek version of the SeaPerch Program, which was created by the MIT Sea Grant College Program in 2003. Hydrobot is a simple remote-controlled underwater which students build the ROV from a kit comprised of low-cost, easily accessible parts. In Greece the program has not yet been implemented by primary school pupils or teachers. In the present study a short-term training course for future teachers of Primary Education in the Hydrobot program has been attempted. By using quantitative tools we investigated a) the ability of participants to built Hydrobot and b) their self-efficacy beliefs in guiding students into the construction of Hydrobot. In addition, we investigated whether these <b>future</b></p>



	<p><b>teachers</b> were able to propose ways of incorporating Hydrobot in teaching, in order to fulfill <b>scientific literacy's</b> goals, that focus on real-context science-related situations, and conducted context analysis on their answers.</p>
<p>Hydrostatic pressure and buoyancy in the high school educational process - creating worksheets and prototypes of DIY, in relation to science fiction and modern technologies as a STEM application</p>	<p>This study has been an attempt to help students in <b>middle school</b> understand the meaning of <b>hydrostatic pressure and buoyancy</b> and apply their knowledge on constructing a submarine. The cause of this study was the difficulty of students to penetrate into these means. A guided experimentation through worksheets, using simple daily materials and examples from everyday life was implemented. The final goals were the increase in students' interest during the course through designing and constructing a submarine, familiarization with problem-solving situations in STEM education and getting in touch with notions such as center of mass, gas compressibility and Pascal's law.</p>

Table 2.2.3.2 STEM relevant Master theses, Year 2019	
Title	Short Abstract
<p>Future preschool and primary school teachers' perceptions about educational robotics and STEM</p>	<p>The present study investigates the attitudes of <b>future pre-school and primary school education teachers</b>, towards educational robotics and STEM. It also explores the perceptions of teachers on their ability to carry it out, as well as the obstacles they</p>





	<p>might encounter when implementing it. Finally, the study examines their perceptions on the impact educational robotics would have on their students. The results of this research indicate the significant impact of teacher training on their ability and confidence to carry out <b>educational robotics</b>. Future teachers are also distinguished for their particularly positive attitude towards educational robotics, recognizing the positive impact on the development of students' skills while being aware of the obstacles they face when implementing it.</p>
<p>Educational robotics as a factor in changing students' attitudes towards STEM sciences: parents' assessments</p>	<p>In this thesis, robotics is examined as an educational tool that can grow the students' interest and create an impact on students' attitudes towards STEM fields. The extent to which the students' involvement in educational robotic activities influences their attitudes towards STEM is investigated. Secondly, student involvement in educational robotics was investigated, as to whether it creates incentives for pursuing a professional career in STEM. To investigate these questions, an anonymous research instrument (questionnaire) was developed for measuring the parents' perspectives, whose children are involved in the educational programs of the University of Macedonia Robotics Academy. According to the research findings, students have positive attitudes towards STEM, regardless of their engagement with robotics. Students' involvement in the robotics educational programs has a positive impact on their attitudes towards STEM. However, students' involvement in robotics cannot be considered the only factor that takes part in shaping attitudes. Educational robotics can be a significant factor, considering STEM-career choices and students' involvement in activities of that kind affects their professional orientation.</p>



<p>The project of educational robotics as a means of supporting the joint educational process of two different classes in a small school.</p>	<p>Beyond the benefits of Educational Robotics in teaching, its positive effects on the emotional and social level of students is equally important. Within this general theoretical framework, the present research work focused on how Educational Robotics can contribute to the joint teaching of the cognitive subject of <b>Mathematics</b> in a small school.</p>
<p>An investigation of teacher's perceptions about gender and STEM</p>	<p>Due to the limited participation of women in study and business disciplines related to the scientific fields of Physics, Mathematics, Technology and Engineering, the interest in the investigation of gender and STEM has been strongly grown up in recent decades. The purpose of this work is an exploration in the relationship between <b>gender and STEM</b>, focusing on the role of education and more specifically, on the teacher / educator. The present study therefore deals with <b>primary school teachers</b> by investigating their perceptions and their level of awareness on various issues arising from gender and STEM. Along with the investigation process, this work aims to inform teachers about these issues through the projection of a series of audiovisual narratives (videos), whose goals are to enrich the participants' minds, make them realize some stereotypical perceptions they hold about the sexes (if they exist) and to overthrow them. The processes of both investigating and informing / sensitizing teachers were done using the same methodological tool that was tailored to meet the specific needs of this research.</p>

Table 2.2.3.3 STEM relevant Master theses, Year 2020



Title	Short Abstract
Comprehension of physics vocabulary by students with special learning disabilities and their typical peers	<p>The purpose of the research was to examine the understanding of physics vocabulary by students with special learning difficulties and their typically developing classmates. For this purpose, the ability of 85 students with and 35 students without <b>special learning difficulties</b> of the second high school was examined and compared, to a) distinguish the special meaning of the words that appear in physics texts, b) replace the words that appear in physics texts with one word that will have exactly the same meaning in physics and c) know the meaning of these words, outside the context of physics texts in their everyday use. The results showed that students with special learning difficulties lag behind in their knowledge of the vocabulary used in the physics textbook, in relation to their corresponding classmates of typical development. They thus highlighted the need for a series of corrective measures in terms of the teaching method and the detailed curriculum in the physics course, including the introduction of the <b>teaching of physics vocabulary</b> and the STEM/STEAM educational policy.</p>
Leveraging social assistance robots in STEM courses: implementation in the STIMEY program	<p>The main goal of Social Assistance Robots is the social interaction between humans and robots. In this work, <b>students' attitudes, opinions and behaviors towards STEM sciences and STIMEY</b> were studied before and after the teaching intervention with the help of the STIMEY robot. In this context, it was investigated what attitude <b>Middle and High School students</b> have towards STEM and robotics. At a second</p>



	<p>level, it was investigated whether after engaging students in a STEM-themed lesson using the robotic assistant STIMEY, it strengthens students' attitudes, opinions and behaviors towards STEM sciences and STIMEY.</p> <p>In order to test these research questions, an anonymous measurement tool (questionnaire) of students' views was developed. According to the survey results, students had a positive view of STEM and STIMEY before and after the activity. Also, the students showed a very positive attitude towards STEM and STIMEY before and after the activity and indeed after the activity their attitude towards STEM and STIMEY became even more positive as they typically consider that the most difficult course for them would become more interesting and easier to understand as well as that the robot would motivate them even more to study this subject in the future.</p>
<p>The impact of the use of 3D Printing technology on content knowledge, stress and student's interest in the Natural Sciences</p>	<p>The present study examines the results of the effect of a project done by students of the <b>5th and 6th grade of Primary School</b> with the use of 3D Printing Technology on content knowledge, anxiety and their interest in <b>natural sciences</b> and the approach of teaching natural sciences. At the same time it compares them with the corresponding results of students who were taught according to the same teaching model. The students who participated in the research were taught the concept of Friction and the factors by which it is influenced by the constructive approach. A questionnaire was used in four thematic sections, which dealt with demographics, content knowledge, and attitudes toward the Natural Sciences. The</p>



	<p>research reveals the positive effect of 3D Printing on the conceptual understanding and learning of the concept of the force of friction and the factors by which it is influenced and confirms that 3D printing technology can be used as a powerful STEM educational tool that supports learning and creativity. Regarding the scientific interest of the students in natural sciences it is determined that it is not affected while it is observed that there is a positive effect of the teaching intervention on the students' anxiety about Natural Sciences.</p>
<p>Design and implementation of a didactic research intervention with original worksheets for 5th Grade Physics in combination with educational robotics</p>	<p>This diploma thesis was written as part of the Postgraduate Program of the University of Piraeus entitled: "E-Learning". The intervention took place at a public Primary School of Athens with the participation of 16 pupils of the <b>5th grade</b>. The main goal of this research is to design, implement and evaluate a teaching intervention for <b>Physics</b> using educational robotics and programming for the concepts of Speed, Power, Mass, Weight and Friction. For this reason, four original worksheets were designed according to the exploratory scientific method, STEM, PBL and cooperative learning. The main research objective is the effect of educational robotics combined with formal education on the performance of students in the course of Physics and their feelings about this intervention. A secondary one is the factor of the sex on the performance of the students in Physics. The research results showed no significant statistical difference between the learning outcomes of the control group and the learning outcomes of the intervention team. Furthermore, there was no significant statistical difference between the two</p>



	sexes. However, students' feelings about this intervention were joy and excitement.
Comparative study of the presence of astronomy in the primary education curricula of 17 countries from 5 continents	<p>The purpose of this study is to conduct a comparative analysis between science curricula for <b>primary school</b> from 17 countries (including countries from 5 different continents) regarding the subject of <b>astronomy</b>. The study is focused on a) the structure (in which subject and in what topic astronomy is being included), b) the context (what concepts and phenomena are students introduced to and in which school years), c) the learning objectives and d) the activities that help reach them. Regarding the activities, the results showed the curricula contained a variety of different types of activities. Most of them were group activities that demanded the students' collaboration and were connected to STEM. Finally, most were low-budget activities, which means that teaching astronomy in primary school isn't financially demanding</p>
Leveraging the Arduino Platform in Education: Designing Learning Activities Based on the ECLiP Framework	<p>In this study the main characteristics of educational robotics and STEM education are discussed. Various educational robotics platforms are presented and analyzed and in particular the Arduino platform which, although not dedicated to educational purposes, has significant advantages in education. The thesis proposes the utilization of the Arduino platform for introducing educational robotics into <b>primary and secondary education</b>. Specifically, it is proposed to design learning activities based on the ECLiP learning activity design framework. The proposal includes enriching ECLiP with educational elements so that it can be applied to educational robotics activities and exploiting alternative programming</p>



	environments for Arduino programming so that different educational situations are supported. In the framework of the thesis five sets of learning activities were designed. Two of them were used and evaluated in the context of the "Didactics of <b>Informatics</b> ". The results reveal that the enriched ECLiP framework is indeed suitable for the design of learning activities combining robotics and programming issues and contributes to a constructive acquisition of new knowledge.
Raspberry Pi in Education: A Literature Review	In the context of teaching the subject of <b>Computer Science</b> , teachers, besides the educational pedagogical approaches they apply, also use appropriate software and hardware tools. A promising computer device is the Raspberry Pi. Given its great potential in education, the purpose of this study is to investigate the use of Raspberry Pi applications in the classroom, as well as to evaluate the contribution of these applications to the learning process. The findings of the study indicate that Raspberry Pi applications are mainly used in the teaching of Computer Science. However, RPi can also be used in the context of interdisciplinary teaching approaches, such as STEM. The integration of RPi in teaching has mainly deployed the method of robotics, while it is applied mainly in <b>secondary education</b> . The feedback given by both students and teachers who participated in classes that utilized the Raspberry Pi platform was very positive.

Table 2.2.3.4 STEM relevant Master theses, Year 2021	
Title	Short Abstract





<p>Utilization of the STIMEY Program Social Assistance Robot and the STIMEY Program Online Platform for Teaching Astronomy Courses</p>	<p>As part of this research, an <b>astronomy</b> course was taught using the STIMEY program "Social Science" robot and the STIMEY program platform to <b>6th grade</b> primary school students. The intervention was designed to replace teaching by a natural person, the teacher, with distance learning, carried out entirely by the STIMEY robot and by the parallel use of the STIMEY web platform, in order to carry out an in-depth observational analysis of students' psychography, with an emphasis on their feelings, reactions, expressions and attitudes towards this new teaching experience, the degree of commitment to the process and cooperation between members.</p>
<p>Teaching weather phenomena in the early years of primary school with digital applications</p>	<p>A study with twenty <b>8-year-old pupils</b> has been carried out aiming to help children understand <b>weather phenomena</b>, meteorological symbols and forecasts, as well as contribute to the basic science literacy concerning meteorology. The main research questions were: a) what should be the characteristics of a series of activities for teaching about the weather in the context of STEM education? b) what educational outcomes should be expected from the application of a series of activities for teaching about the weather in the context of STEM education to 8-year-old pupils in primary education? The results from the application were very encouraging. Children managed to use and understand the terminology of weather phenomena in order to decide how to dress and what accessories to carry. They observed the weather, kept records of temperature and other weather characteristics,</p>



	<p>chose the most suitable outfit and depicted weather phenomena in their drawings. Beebot-meteo combines educational robotics, simple programming, meteorological maps and weather prediction and introduces children to the scientific method of “trial and error”. Children became familiar with using meteorological maps and weather symbols, while dynamic digital maps help children understand the evolution of weather phenomena.</p>
<p>e-STEEM: A design of online lessons based on inquiry learning for science teaching</p>	<p>The purpose of this thesis was the design of an online platform which included a series of activities that promote inquiry learning for learning <b>Science</b> and was addressed to students of the <b>fifth and sixth grade</b> of primary school. The educational proposal entitled “e-STEEM” was based on the principles of online learning (e-), STEM education and Entertainment Education (E). The main goal was to evaluate the impact of this educational proposal on students’ motivation, the stimulation of previous knowledge, the facilitation of the learning process, the correlation of the knowledge produced with situations of everyday life and the increase of the probability that the student will recall information about the subject.</p>
<p>Studying changes on the Earth’s surface with the use of satellite imagery: A teaching proposal for primary education</p>	<p>The purpose of this thesis was to create a comprehensive teaching proposal for <b>Primary School</b> about the changes on the Earth's surface, a subject included in the Curriculum of <b>Geography</b>. The intense interest of children in space and the view of the Earth, as seen from above, creates suitable conditions for the integration of satellite imagery in the teaching of various subjects. Satellite imagery is the</p>



	<p>most appropriate resource, in order to visualize changes that occur on Earth's surface, which -in many cases- are not perceived from the ground. At the same time, the teaching design is based on the principles of STEM education: multiple subjects are integrated into a single teaching. In addition, the implementation of the teaching proposal enabled evaluation and adjustment, in order to improve it. The interest of the research also focused on the attitude of the teachers for this proposal.</p>
<p>Teaching and learning mathematics in primary education in a CSCL environment through the interdisciplinary (STEM) approach</p>	<p>This work investigated whether the interdisciplinary approach could be beneficial for the teaching and learning of <b>Mathematics</b> in <b>Primary education</b>. Specifically, the scenario was orchestrated through PBL (Problem Based Learning), combining it with the "6 Thinking Hats" strategy, in a technologically supported environment, such as Edmodo. In order to achieve the interdisciplinary approach, a learning scenario was created, in which an attempt was made to combine Mathematics with the subject of <b>Physics</b>. To support this aim, about 30 trainees participated in the distance learning program. From the data collected it appeared that the educational intervention was successful and suggestions for further research were presented.</p>
<p>Action research to study collaborative problem solving in the Environmental Studies at Primary School during emergency remote teaching due to COVID19 pandemic</p>	<p>Collaborative problem solving (CPS) is one of the key skills required in our time. The current research attempts to enhance collaborative learning in distance education by cultivating collaborative problem-solving skills in <b>4th grade</b> students in primary school in the context of the interdisciplinary course of <b>Environmental Education</b>. For the</p>



	<p>purposes of the research, an educational intervention of STEAM activities was developed, based on Problem Based Learning, which follows the CPS procedures. It examines awareness in collaborative problem solving and at the same time explores students' attitudes about collaborative learning in online environments. This study aims to identify possible factors that affect the use of CPS skills in students' attitudes towards collaborative learning in the environment of the WebEx Meetings platform which was used to implement it. The results, as obtained from questionnaires and evaluations, confirm the positive effect of this educational experience on CPS awareness and the emergence of social skills behaviors in students at that time. At the same time, the research findings did not show a correlation between the awareness of CPS and the positive attitudes of students, but a significant positive correlation was observed between positive attitudes and the dimensions of Social CPS skills (Participation, Perspective Talking and Social regulation).</p>
<p>Interdisciplinary STEM Teaching Model: Design and Development of Instructional Materials Using the Arduino Platform.</p>	<p>The present work proposes a series of four workshops for <b>high school students</b> that put into practice the STEM teaching model. On the occasion of making measurements for different <b>atmospheric</b> quantities, the teacher has the opportunity to combine elements from different scientific fields to achieve the educational goals and to introduce alternative teaching techniques in the educational process. The students expand their skills, acquire new knowledge, recall old ones and apply them in practice. They build, make measurements, check the results</p>



	and solve problems. They use mathematics (functions, diagrams, etc.) to utilize sensor data and relate it to device programming. They come into contact with sensors and electronic components, write code, evaluate data, and use the IoT to present it. They develop beliefs and form attitudes on issues related to technological progress, climate change, etc. The Arduino platform was used to build and program the device.
Agents of the Environment vs. Modern Monsters: An Educational Intervention to Protect the Environment Using Digital Games and STEM Education for Secondary School Students	This work analyses the Digital Game-Based Learning industry and its contribution to <b>Primary Education</b> , specifically to <b>Environmental education</b> . Studies are presented, which examine the use of the Minecraft Education Edition game to introduce students to STEM Education and the results of those studies. The educational intervention is presented through a detailed presentation of the steps of implementation. The results from the assessments are analyzed, recorded and presented. The presentation is implemented through diagrams but also a "knowledge ruler-amplifier" in which the correct answers, given by the students per stage, are marked. The last part of the work concerns the conclusions that were formulated from the measurements implemented and recorded, as well as thoughts and ideas for future extensions of this educational intervention.

Table 2.2.3.5 STEM relevant Master theses, Year 2022	
Title	Short Abstract



<p>The impact of STEM on mathematics in early childhood education</p>	<p>The questions of this study were the following:</p> <ul style="list-style-type: none"> <li>• What math skills do children develop with STEM instruction?</li> <li>• What are the benefits to children's math skills through STEM instruction?</li> </ul> <p>A model for teaching <b>mathematics</b> to <b>preschool</b> children (4-6), including STEM education, is proposed. This specific teaching model aims to teach numbers 1-5 to kindergarten children. The main goal was both number recognition and quantitative matching. The teaching is mainly based on STEM activities and developing robot programming skills using Bee-Bot.</p>
<p>The STEM methodology in technical-vocational education</p>	<p>This thesis seeks to explore the potential for more systematic implementation of STEM education in <b>vocational high schools</b>. More specifically, it examines what are the necessary conditions, logistical and teacher training, in order to facilitate STEM education in the different areas of vocational high school, suggests changes that should be made to enable its implementation, presents the tools that teachers can use to create STEM lessons as well as a comprehensive STEM lesson plan.</p>
<p>Robotics and information technologies in education: Exploring teachers' attitudes to the use of social robots in the classroom.</p>	<p>This research aims to study the impact of educational robotics in Greece. In particular, the views of <b>in-service teachers</b> on educational robotics are explored. Potential issues, needs and problems are identified, which according to teachers, are raised from the introduction of robotics and computer science in the educational process.</p>



	<p>The conclusions can be used to propose strategies and methods, aimed at strengthening the integration of information technology and robotics in the teaching process.</p>
<p>Implementation of STEAM teaching in Greece: Exploring teachers' perceptions</p>	<p>In this study, the attitudes and perceptions of teachers related to STEM issues were investigated, as well as the ways of their application. A questionnaire was used for data collection, in order to examine the perceptions and practices of STEM education of in-service teachers. The results of this study revealed that educators generally show positive perceptions of STEAM, while in terms of their application they choose interdisciplinary approaches, so as to involve several subjects at the same time.</p>
<p>Readiness Of Primary and Secondary Education Teachers to Implement STEM Activities: Cognitive and Emotional Dimension</p>	<p>The purpose of this paper is to investigate the level of readiness of teachers in Greece, for the implementation of STEM education. The research was carried out online with the participation of 494 teachers from all over Greece, regardless of specialty. Findings indicated that teachers have a positive attitude and are committed to implementing STEM-based learning. However, they seem to be less emotionally prepared and to a large extent feel that they are not effective enough in teaching this methodology in the classroom. Furthermore, the demographic characteristics of the participants greatly influence their attitudes and readiness towards STEM.</p>
<p>Increasing the active participation of preschool children in</p>	<p>The emphasis given to the increase of interest and the motivation of the students' involvement was a trigger for</p>





the curriculum through the STE(A)M approach	the use of the specific method in <b>preschool education</b> , to observe an increase or not, in the active participation of preschoolers in the Analytical Curriculum of the Kindergarten. Curriculum courses were modified or replaced with STE(A)M-based lesson plans to identify variation in classroom participation. The results of the research were encouraging as there was an increased or equal participation of the students, without showing any decrease in participation in the learning process. As it turned out, the STE(A)M methodology had a positive effect on young students and can contribute to their encouragement, motivation, and involvement in the daily program.
Teacher's attitude towards S.T.E.M in secondary education	The main purpose of this study was to examine the level of <b>secondary education teachers'</b> attitudes towards the implementation of S.T.E.M. in the classroom. Moreover, the findings of previous relative research studies were reviewed in order to assist in the analysis of the current study. The results showed a highly positive attitude towards S.T.E.M. education. Nevertheless, teachers seem to be concerned in regard to the implementation of the framework in the classroom, appearing willing to participate in relative seminars. Overall, the findings of this study comply with the findings of the international literature and are expected to raise awareness among the relevant departments of the Hellenic Ministry of Education and Religious Affairs.
The role of digital applications to self-perceived	This thesis studies the impact of digital applications in 2 main fields, self-perceived content knowledge of



student's content knowledge from Departments of Science, Technology, Engineering and Mathematics (STEM) and self-confidence for employment	<b>university students</b> in the fields of Science, Technology, Engineering and Mathematics, as well as their confidence regarding their employability. The main results show that students consider the use of digital applications to be important in their field of study and affect the quality of their knowledge. Moreover, they consider that they develop their practical skills, while they also believe that the knowledge of digital applications gives them more job opportunities and confidence.
The creative thinking of children of early school age, through STEAM activities	The purpose of this study was to highlight the creativity of early school-age children through STEAM activities, and how activities through STEAM methodology affect children's creativity. The classes attended were <b>kindergarten, A-B and mainly third grade primary school</b> . Particular objectives were to examine how groups interacted and exchanged views with each other. At the same time the role of the teacher in the educational process was investigated. In younger students (such as kindergarten) although children have creative ideas at this age, the lesson was guided so there was no possibility of new ideas from the children. Subsequently, the research was modified and more open-ended lessons at older ages were attended (1st, 2nd & 3rd grade primary school). The results showed that children show their creativity through creative problem solving.
The Arduino microcontroller as a programming learning tool in primary education	This master thesis deals with using Arduino Microcontroller as a programming learning tool in <b>Elementary Education</b> as a part of the Informatics Class. For this purpose, ten programming activities based on Arduino



	<p>UNO have been created. This gives the impetus and direction to teachers who have no previous involvement with educational robotics and the Arduino platform. Also, for programming the platform it presents a software that has not been widely used and which can be used for other popular robotics platforms thus maintaining an educational continuity for the students.</p>
Utilization of the internet of things (IoT) for creative stem education	<p>This paper proposes the use of IoT in STEM education for students of the <b>last grades of Primary Schools</b> with appropriate applications adapted to the age and abilities of students. The work presents in detail characteristic applications, familiar from everyday life, that will introduce students in time to an environment that is changing very fast, in the world of Internet of Things. They are applications in the Arduino Uno, which communicate wirelessly, using Bluetooth modules, with smartphones from which we can control the various functions.</p>
Design and Implementation of Interdisciplinary Teaching Activities: leveraging STEM approaches to teach programming in the school unit	<p>This postgraduate thesis presents the implementation of seven laboratory cycles of a skills program with the ultimate goal of acquiring <b>basic programming skills</b> in a playful way through the Scratch visual programming environment, for <b>High School students</b>, based on the STEM methodology. Two axes of interest were investigated, firstly if the programming environment of Scratch, with a STEM approach, shapes students' attitudes, actions and values, simultaneously cultivating the learning skills of the 21st century or 4Cs (creativity, communication, collaboration, critical thinking ) and consequently if the</p>



	design and implementation of a STEM program for High School children is a suitable option for cultivating programming, (modeling/simulation) and computational thinking skills, approaching basic principles of Programming through the visual environment of Scratch. Learning benefits of the students from the implemented scheme of STEM education, were: enthusiasm, proposing solutions to real problems, engaging in simulations / game creation, research spirit and knowledge building.
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Table 2.2.3.6 STEM relevant Master theses, Year 2023	
Title	Short Abstract
Simulated Electronic Learning in Secondary Education	This work was composed in the context of capturing the impact of STEM teaching and the effect of the latter on the creation of courses for <b>high school students</b> in Greece. The case study concerned the <b>physics</b> course. The experiential and exploratory approach to knowledge with the use of digital technological products seems to help students to engage actively and with greater willingness in the activities that take place in the classroom and thus to more effectively conquer the cognitive goals of the course. Also, the interaction of the students, in the context of Cooperative Learning, seems to create suitable conditions for the development of their soft skills.

The PhD dissertations are considered for the same time period. Openarchives and the National Archive of PhD Theses (<https://www.didaktorika.gr/>) were surveyed. The National Archive of PhD Theses collects, in digital form, doctoral dissertations awarded by Higher Education Institutions (HEIs) in Greece



as well as Ph.D. theses awarded to Greek scholars by foreign HEIs and certified by the Hellenic National Academic Recognition and Information Center.

A total of 11 PhD dissertations were retrieved. Their content is briefly presented in chronological order in tables 2.2.3.7 – 2.2..311.

Table 2.2.3.7 STEM relevant PhD theses, Year 2019	
Title	Short Abstract
Teacher skills in developing educational robotics scenarios: exploring and designing an appropriate teacher preparation framework	<p>The present dissertation attempts to integrate Educational Robotics (ER) into the curriculum of the Department of Primary Education (Teacher Training for Primary Education). It presents an exploration of possibilities offered by ER in the reorientation of basic training in Education for future teachers, with the aim of producing teaching material and integrating it into everyday teaching practice, through the creation of didactic scenarios. The research objective is the dismantling of parts that compose the learning process with the use of the ER and the identification of those elements which affect learning outcomes, such as motivation, goals, usability, hardware management, adaptability difficulties and factors university students themselves consider important. The participants learned to design, construct and <b>program robotic</b> artifacts by following engineering principles and went from "learning ER" to "teaching with ER" based on the framework of Technological Pedagogical Content Knowledge (TPACK). The main contribution of this research was the customization and adaptation of an ER course for the preparation of future teachers and cover the needs of the primary education curriculum, through experiential learning processes of problem solving. The methodology chosen as</p>



the most appropriate was Action Research (AR), as the process of conducting it aims simultaneously at changing and improving the educational process through repeated interventions and has been applied for six consecutive years. This empirical research began to identify variables and factors related to the teaching of ER to future teachers. Major deficiencies were identified in Coding and Engineering, as well as in general Science and Technology Literacy (STL), covering didactic course weakness related to materials. The research results have shown that future teachers with appropriate preparation are able to develop didactic scenarios, especially in **Science and Mathematics**. Interventions revealed that using hands-on learning pathways with ER has had a positive change in attitude towards technology and increased self-esteem for its use in teaching. Participants feel more capable of "Teaching with ER" through the use, creation and extension of ER's curriculum scenarios and less of the "Teaching ER" with the fear of technical problems and time of implementation. The didactic scenarios were aimed at enhancing learning, experimentation and interdisciplinary approaches, and used the robot as a enchanting learning tool with a playful role. The dissertation focuses on the effective rearrangement of the teaching process; the sequence of teaching subjects and the administration of the teaching class duration, utilizing the ER and aims at an "effective classroom". It demands comprehensive preparation from the future teachers, especially by incorporating experiential ER activities in the program of studies. Lastly, it recognizes the importance of prerequisite knowledge in STEM, in order to shape a scientific and technological culture.



Table 2.2.3.8 STEM relevant PhD theses, Year 2020

Title	Short Abstract
<p>Cinema art and technique through virtual learning environments: machinima case in the Greek educational system</p>	<p>Digital content production for educational purposes is a trend to be applied in the educational system of many countries, nowadays. Cinema, digital storytelling, comics, animations, serious games, virtual and augmented reality techniques, and STEM/STEAM are techniques (or arts, some of them) already used in education. Many of these arts/techniques, as components and/or complementary elements, are completed in the machinima technique, a hybrid form which is a popular case of creating and consuming educational content at the research level in recent years, adjusted to the requirements of the new generation of students of the digital age, according to the main directions of the Pedagogical Institute and the Ministry of Education. With extensive bibliographic references, the correlations of cinema and film education with modern education were sought. A research was carried out in the context of this paper with a focus on machinima and its introduction into the Greek educational system, more specifically, in primary education. The young students came in contact with the capabilities of a virtual environment and were trained in techniques related to <b>film education</b>. Then, along with educators and external observers, they took part in a survey, along with interviews and observations, forming a valuation framework with quantitative and qualitative methods. Research data derived from the experimental application of the machinima hybrid film technique to pupils of a typical Greek elementary school can be set</p>





	as the starting point for discussing the application of machinima in the school curriculum in various educational subjects.
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Table 2.2.3.9 STEM relevant PhD theses, Year 2021	
Title	Short Abstract
Playful interactive storytelling as a method of transmission of cultural content	<p>The subject area of this thesis concerned the use of <b>serious games</b> in the domain of <b>cultural heritage</b>. In particular, its basic scope was the creation and evaluation of a collaborative narrative-based game, which can communicate cultural content, in formal and non-formal educational settings. First, the notions of play and games, which constitute overarching concepts in this thesis, are defined. Afterwards, current approaches integrating games with learning purposes are presented. Their application in the field of cultural heritage has been examined in literature reviews preceding the thesis. However, to better understand the function of games regarding cultural sites, a systematic literature review, focusing on this narrower area, was conducted. The review investigated: a) how different game genres handle cultural content, b) the relationship between gameplay, exploration and narrative, c) the games context of use, d) the social relationships they enable and e) their reported outcomes. One conclusion of the aforementioned review was that storytelling is used in games regarding cultural places, but often in a simple form. Using a narrative-based design for educational purposes is supported by several researchers, however results on the effectiveness of this approach are contradictory and further empirical data are still needed. Moreover, a combined use of cooperation and competition was found only in a few location-based</p>



	<p>games, an observation which aligns with researchers indicating this shortage and advocating this approach for learning purposes. Based on the above observations, the next aim of the thesis was the design of the story-driven game Tracers of the Past. This is based on the incorporation of scientific information—regarding tangible/intangible cultural heritage and history—into fictional narratives, additionally taking advantage of endogenous cooperation and competition. The design was implemented first as a paper-based board game and next as an interactive fiction game. The latter was developed with the authoring tool Twine and uses features of Classroom Multiplayer Presential Games, a model previously applied in games dealing with STEM subjects. Both versions of the game were evaluated, in regard to playability, learning outcomes, enjoyment, engagement and social interaction, with <b>teenage and adult participants</b> in formal and non-formal educational settings, following a multiple case research design. The evaluation included initially an exploratory study following a qualitative research methodology and next, a main study following a mixed research methodology. Apart from the individual results of the interventions with both versions of the game, an overall discussion of all the conducted interventions was attempted. These confirmed the playability of the analogue and the digital implementation of the design and its potential to offer enjoyment while facilitating collaboration and argumentation between teammates. Furthermore, the outcomes of the interventions can be considered positive in respect to the potential of the game to offer learning gains and mostly to motivate participants towards its cultural content, and to enhance engagement.</p>
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<p>Augmented Reality in Secondary Education in the field of STEM: a case study with schoolteachers in Cyprus and Greece</p>	<p>This study aimed to tackle to some extent the gap between the instruction of STEM-related disciplines in Lower Secondary Education and the 21st century skills required by students, to face real life situations in their future STEM related studies and careers. Following the necessity towards “smart education”, Augmented Reality has been integrated in Lower Secondary Education by teachers of STEM-related courses in the context of a case study with two cases, one public school in Cyprus and one private school in Greece, to explore the impact on the teachers involved as well as their students. This Ph.D. dissertation provides the context of an empirical investigation, yielding a theoretical understanding of the discussed fields that can constitute the basis for future work. The research purpose is investigated in-depth through a case study with multiple units of analysis defined as “The Case Study of Secondary Education Teachers’ Experience from Cyprus and Greece having attended a Teacher Professional Development (TPD) program on Augmented Reality in STEM education”. This case study consists of a systemic approach, including a small number of cases set in their real-world contexts, providing understanding to some extent of the impact of applying AR in Lower Secondary Education on teachers of STEM-related courses and their students. Both quantitative and qualitative data were collected, analyzed and triangulated through questionnaires/ self-reports, interviews, informal and open-ended discussions, observations, video recordings (where/ when possible), and teachers’-students’ additional data (i.e., lesson plans, worksheets, achievements). Twenty-seven (27) teachers have been trained, from whom five (5) have accepted to be observed while implementing AR supported interventions in their classrooms and one hundred and seventy-nine (179) students, have attended the AR</p>
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	<p>supported interventions. Through the discussion and interpretation of the cases described, the involved teachers are investigated towards: (i) the level of technology acceptance (AR) and (ii) their instructional approaches adapted to integrate AR in STEM-related courses. Concurrently, the effect of the teachers' instructional approaches supported by AR in their STEM-related courses is investigated on their students' 21st century skills and motivation towards the educational process. The conclusions of this dissertation indicate that the implementation of AR applications in STEM fields by both teachers and students seems to be currently feasible under specific conditions. Moreover, there is a need for continuous and structured teacher training on emerging technologies, such as AR, accompanied by innovative instructional approaches. Based on results of existing studies, contributing to the literature review, this research suggests: (a) factors that influence to some extent the level of technology acceptance (AR) by teachers in their instructional approaches within a STEM-related course and (b) ways that AR technology could be integrated by Secondary Education teachers in their STEM-related courses.</p>
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Table 2.2.3.10 STEM relevant PhD theses, Year 2022	
Title	Short Abstract
Education of students of general or special education due to inclusion in general schools of Primary Education in sudden and extreme natural disasters through STEAM	The object of this research was to investigate if and to what extent, the holistic -interdisciplinary approach STEAM, that uses in a holistic approach Science, Technology, Mechanics, Art and Mathematics, can be used to teach natural disasters as effectively to pupils that need



	<p>differentiated teaching, because of learning disabilities, as opposed to pupils that don't. Two questionnaires were created, which addressed teachers and pupils of the Greek territory. Through these, the desire of all of the teaching staff and the pupils' population for education related to natural disasters was made clear. A work plan including many different activities related to natural disasters, was created, which aimed to give pupils who took part in a differentiated manner, multiple stimuli through different interventions and artifacts. Stories were created, electronic and board games, experiential workshops, field study (burnt forest), painting competitions, creation of musical sounds, educational trips, video watching and also activities related to emotions. After the educational material and work plan was created at the school units that took part, two questionnaires were designed to estimate the situation at the beginning and to evaluate the results after the educational program. The educational program took place in school units within the lesson: «Skills workshop» and for the topics: «I take care of the environment – Natural disasters», «Civil protection» and «I create and innovate- Creative thinking and initiative – STEM». During the phase of implementation, it was decided that two questionnaires should be given to pupils. One at the start of the program and one after the course of their employment with the object of natural disasters. The questionnaires that were distributed had a unique code for every pupil, which allowed us to know if they were in need of special education, hence differentiated teaching. There was</p>
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	<p>cooperation with ten teachers, who were first educated in relation to the content of the activities and then cooperated with the researcher in order to exchange information and to export and at the same time evaluate the findings. The results pointed out the need of the population of both teachers and pupils for educational programs related to natural disasters. As the study progressed it became apparent that the holistic - interdisciplinary education STEAM, was able to bring positive learning outcomes to the whole of the pupils ' population, smoothing out the differences and making use of the abilities of all the children without allowing exclusions.</p>
Development and exploitation of Arduino devices in science education	<p>This dissertation described the development and exploitation of Arduino-based artifacts, in a Makerspace that operated in <b>secondary education schools</b>. More specifically, by starting with simple, small constructions using increased educational guidance, students develop the necessary knowledge and skills regarding Arduino technology. Afterwards, they proceed to the development of more complicated artifacts such as Arduino laboratory instruments and Smart devices that exploit in out-of-school projects, during the formal <b>Chemistry</b> education and in everyday applications. Firstly, a Makerspace was developed in a Greek Junior High School where students developed Chemistry laboratory instruments such as pH meters and Salinity meters. Students' stances regarding their participation in the Makerspace were evaluated using a questionnaire based on the development of intrinsic</p>



	<p>motivation. The results showed that the intrinsic cognitive load of the activities was medium, the extrinsic cognitive load was small, and the germane cognitive load was large. The students also stated that the activities were interesting and helped them expand their knowledge about STEM subjects. Students also expressed their intention to participate in similar Makerspaces in the future. However, their participation in the Makerspace had medium effects on their choice of future studies. These results highlight the fulfillment of the basic need of students for Competence, Relatedness and Autonomy which, based on the Self-Determination Theory, induce the development of intrinsic motives and consequently the learning outcomes. The acquisition of declarative knowledge during teaching with Arduino experiments by demonstration on the Interactive Board, was evaluated. Declarative knowledge acquisition was compared with two other common Greek educational practices, teaching with experiments using a Virtual Lab and teaching without the use of experiments. Three student groups participated in the research. The first group was taught about Acids-Bases through experiments by using the pH meter-Arduino and typical Chemistry laboratory instruments such as beakers and volumetric cylinders and laboratory substances and everyday products. The second group was taught through the corresponding experiments in the Virtual Laboratory and the third one through static representations of the typical laboratory instruments and substances. Based on the results the first and the second group had equivalent</p>
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	<p>learning outcomes, which were higher than those of the third group. Therefore, Arduino laboratory instruments can be utilized in combination with typical laboratory glassware and chemical substances for the implementation of experiments by demonstration, with equivalent learning outcomes with the use of the Virtual Laboratory. Furthermore, the Arduino-based pH meter was used to implement experiments through demonstration on Digital Entities that represented Real ones which are related to students' everyday experiences. Students and teachers of three Junior High Schools participated in the research. The students in each school were distributed in two groups. The first group was taught about Acid-Bases through Arduino experiments on a Digital Entities. These represented a shoal of goldfish, an ancient Greek marble temple and an ancient Greek metallic statue. The second group was taught with the same Arduino experiments but without the use of the Digital Entities. The results showed that the first group had better learning outcomes than the second one in terms of declarative knowledge acquisition. These results highlight that the use of Arduino experiments by demonstration and the use of simulations as test-beds have complementary learning outcomes. Therefore, Digital Entities can be used for Arduino experiments when the Real ones cannot be used for experimentation.</p>
Development of a low-cost robotic platform based on the exploitation of action research	STEM-based education faces several challenges when implementing it in practice since it requires the existence of an organized environment, the necessary logistical infrastructure (robotics - STEM educational



findings for STEM education and educational robotics	platforms, specialized software, properly designed spaces, laboratories, etc.), and of course, the properly trained teachers who will be responsible for the coordination of the project; several publications have identified these. This study investigated whether action research can contribute to designing and developing an educational robotics platform for use in STEM education and Educational Robotics. For this reason, many surveys (N=14) were conducted to determine the robot's specifications and, evaluate the robot's construction and programming. Based on the research's findings, the proposed robotic platform was effectively designed through action research, and the educational community contributed to its development. This assertion was supported by data collected in-person and online, questionnaires, interviews, observations, surveys, program analysis, and focus groups. During the design phase of the robotic platform, several ideas were formulated, and several prototypes were designed since the feedback from the educational community was rich and substantial.
An open hardware mechanism for remote delivery of laboratory activities in science, STEAM, and educational robotics environments: development, usability, and technology acceptance among educators	The aim of the dissertation was to design and develop an educational tool, with open hardware which is used by teachers in the distance implementation of laboratory activities in the teaching of Science, STEAM and Educational Robotics, in educational environments. This training mechanism was designed so that the teacher could create his own remote laboratory activities without the complexity of closed systems. The evaluation involved students of the program EPPAIK of ASPAITE in a series of



	<p>operations and evaluations. The research investigated a) the Technological Anxiety and the expectations of the remote open source mechanisms for laboratory exercises, b) the Usability of the system and c) the evaluation of the educational mechanism (open hardware) for remote implementation of laboratory activities through a proposed, modified model of the Unified Theory of Acceptance and Use. The results showed the positive contribution of the mechanism of the dissertation to the distance implementation of laboratory activities in the teaching of Natural Sciences, STEAM and Educational Robotics, in educational environments.</p>
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Table 2.2.3.11 STEM relevant PhD theses, Year 2023	
Title	Short Abstract
<p>The use of drones in education in the context of mobile learning and STEM education</p>	<p>The aim of this study was the examination on the use of drones and mobile learning applications from in-service teachers, that relies on a STEM-based scenario. Furthermore, usability, self-efficacy, spatial presence as well as simulator sickness of drones for teaching and learning were examined. The sample consisted of in-service <b>primary and secondary education teachers</b> that prior to participating in the study, attended an educational seminar regarding the drone's technological and educational use cases. The STEM-based scenario was developed based on Engineering Design Process and included solving a real-</p>



	<p>world problem. Two pre-assembled quadcopter drones were used in the study, namely DJI Tello educational drone as well as DJI Avata First-Person view drone kit. The STEM-based scenario required that the teachers fly the later drone using its dedicated joystick and head mounted displays in order to collect data and find the optimal route. Then, the teachers had to use a tablet and the mobile application droneblocks to create a block-based code for the Tello drone in order to complete the STEM-based scenario. Quantitative data was collected using Systems Usability Scale, Self-Efficacy in Human Robot Interaction, Temple Presence Inventory Spatial Presence and Simulator Sickness Questionnaire. Additionally, qualitative data was collected with semi-structured interviews and participant comments to an open-ended question. Lastly, data was collected from the block-based code that was developed. Results revealed that the teachers do in fact recognize both drones' usability and spatial presence and they also feel confident in using the drone on their own. Simulator Sickness scored low on both drones and based in SOLO analysis most of the teachers managed to successfully code the drone. These findings will contribute to a better understanding of the educational value of drones for STEM teaching and, at the same time, provide a base-layer for future research in using drones for educational purposes.</p>
Experimentation and educational methods in modern physics	<p>This doctoral thesis was situated within the scientific field of <b>Physics</b> Education Research (P.E.R.). The aim the research was to improve the effectiveness of real and practical (hands-on) experimental teaching of Physics, according to the findings of recent, international research tendencies, as well as to introduce an active approach to learning through applying a learning-by-</p>



	<p>doing (LBD) method. Qualitative and quantitative research conducted showed that students profit significantly by applying such teaching methodologies, starting from primary school and all the way to the higher educational level, as far as the understanding of natural laws and principles is concerned, both by male and female students, as well as by male and female physics educators. This work extensively studied the introduction of scientific methodology and scientific thinking in education through actual physics experiments utilizing simple materials. This thesis highlighted specific difficulties that students face in the context of the school laboratory and the various challenges they encounter in their efforts to understand the basic laws and principles of modern science. According to the arguments presented in this work, the creation of innovative educational scenarios and modern projects in Physics at the compulsory education level, as well as teaching natural sciences through interactive learning strategies, are important and should become the new standard in Physics education. The research also confirms the hypothesis that age is not a barrier to experimental teaching of classical and modern Physics, as long as the teaching methods applied are able to bypass the use of complex mathematical equations and computational procedures. When the proposed experiments were introduced to male and female students, impressive receptivity was observed to the laws of Physics; correspondingly, students were more eager to interpret complex scientific models when these were introduced to them through actual, hands-on experiments. This also shows that the basic principles of electrical circuits and electromagnetism can be taught more effectively through a</p>
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	<p>hands-on approach than a purely theoretical one. Overall, this thesis highlights the importance of innovative and interactive teaching methodologies in enhancing students' learning experiences and their understanding of the principles of Physics. Teaching modern topics in Physics through hands-on experiments with simple materials in the laboratory has been shown to cultivate critical thinking and can help students to acquire a satisfactory level of understanding of fundamental physical laws and principles, regardless to the pupils' previous knowledge, according to the initial research hypothesis. The student conquers scientific adequacy through real, novel experiences in the lab and through the difficulties encountered during experimentation and any actual attempts to resolve them.</p>
<p>Interactivity and learning: the integration of robotics competitions into the educational process: design, implementation, evaluation</p>	<p>This thesis highlightes as key points that a) The dynamic of education in the new era is expressed by its ever-changing character b) Students refuse to be passive receivers and seek a more active role in learning c) Teachers seek interdisciplinarity in their teaching and also to compare and contrast theoretical knowledge with familiar real-world situations d) Educational robotics is the answer to these pursuits, as it gives students the leading role in the educational process along with the ability to build knowledge e) The interdisciplinary approach to teaching achieved through robotics brings together the theory of the course with solutions to everyday practical problems and f) The competitions are the vehicle for introducing educational robotics into school life as these were revealed through setting up an event of an educational robotics competition from zero level. This work provides empirical insights on the design and</p>



	<p>organization of the competition for six consecutive years. It outlines the participating students' characteristics and underlines the changes the competition may bring upon them. It presents and analyzes statistics collected through questionnaires in different periods: before the competition, directly after it and six months after its completion. Among other things, this thesis aims to highlight the changes in the design of an in-person educational robotics competition in order to convert it into an online one, to study how these have been implemented and what conclusions have arisen, while at the same time it records the benefits and drawbacks of the new way of conducting robotics competitions.</p>
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#### 2.2.4. Summary

There is a series of undergraduate and postgraduate courses offered by Universities in Greece. There are also 37 relevant Master's and 11 PhD theses.

The results show that Education Departments are the Departments that offer STEM relevant studies in undergraduate level.

Some Masters as well as PhD theses follow integrated STEM approach, others concern a certain topic from the STEM fields, and few study attitudes towards STEM education.





### 3 Projects

A series of research and development projects relevant to STEM education run and involve partners from Greece.

#### 3.1. HORIZON 2020 projects

Horizon 2020 was the EU's research and innovation funding programme from 2014-2020.

1. *“Partnerships for science education – PAFSE”, <https://pafse.eu/>*

“PAFSE is a science education project that addresses the challenges of public health. PAFSE explores science education as a vehicle to provide citizens the knowledge, tools and skills to make informed decisions on public health challenges. The project promotes community preparedness, by focusing on risk factors for the health condition of individuals, but also on the pre-emptive and protective behaviours from a personal and population perspective, contributing to more literate communities on healthy lifestyles, injury prevention, as well as detection, prevention, and response to infectious diseases. PAFSE establishes partnerships between schools, universities, non-formal education providers, enterprises, and civil society organisations, and engages them in efforts to enrich Science, Technology, Engineering, Mathematics (STEM) education to include public health issues. With a focus on building a strong interdisciplinary team, the project consortium integrates in the educational programme views from biologists, psychologists, environmental health specialists, mathematicians, engineers, project managers, science educators, public health professionals, policy makers and researchers”.

University of Ioannina (Tassos Anastasios Mikropoulos) and Computer Technology Institute and Press “Diophantus” (Elina Megalou) are the partners from Greece.

This project has received funding from the European Union’s Horizon 2020 research and innovation program under grant agreement No 101006468.

2. *Educational Robotics for STEM*  
[http://etl.ppp.uoa.gr/\\_content/Erga\\_R@D/er4stem\\_en.htm](http://etl.ppp.uoa.gr/_content/Erga_R@D/er4stem_en.htm)

“The Educational Robotics for STEM (ER4STEM) project aims to turn curious young children into young adults passionate about science and technology with a hands-on use case: robotics. The domain of robotics represents a multidisciplinary and highly innovative field encompassing physics, maths,



informatics and even industrial design as well as social sciences. Moreover, due to various application domains, teamwork, creativity and entrepreneurial skills are required for the design, programming and innovative exploitation of robots and robotic services. ER4STEM will refine, unify and enhance current European approaches to STEM education through robotics in one open operational and conceptual framework. The concept is founded on three important pillars of constructionism: 1. engaging with powerful ideas, 2. building on personal interests, and 3. learning through making (or presenting ideas with tangible artefacts). The ER4STEM framework will coherently offer students aged 7 to 18 as well as their educators different perspectives and approaches to find their interests and strengths in robotics to pursue STEM careers through robotics and semi-autonomous smart devices. At the same time students will learn about technology (e.g. circuits), about a domain (e.g. math) and acquire skills (e.g. collaborating, coding). Innovative approaches will be developed to achieve an integrated and consistent concept that picks children up at different ages, beginning in primary school and accompany them until graduation from secondary school. Robots increase students' interest in science and promote inspiration to a life-long interest in science, technology, engineering and mathematics starting at a young age, as the EU-funded ER4STEM project brings robots into the classroom".

University of Athens Educational Technology Lab is the partner from Greece.

This project has received funding from the European Community, H2020-EU.5.a, SEAC-1-2014 - Innovative ways to make science education and scientific careers attractive to young people 2015-2018.

3. *Scientix, the community for science education for Europe* <https://www.scientix.eu/home>

The STE(A)M Education European Roadmap (SEER) project seeks to strengthen STE(A)M education in Europe, through the production of a series of roadmaps that will pave the way for policies and institutional changes necessary for the large-scale implementation and integration of STE(A)M education in Europe. To achieve this far-reaching goal, the SEER will synthesize the status of STE(A)M Education and evaluate national and international policies to understand which policy settings best support STE(A)M education. Using the deep and extensive approach, the SEER will design a set of milestones, trajectories, and strategies for key stakeholders, including policymakers, school decision makers, teachers, and industry partners, to support the uptake of STE(A)M education in Europe and beyond. The SEER project is co-financed by the European Commission through the EU Horizon program (HORIZON-WIDERA-2021-ERA-01-70 – HORIZON-CSA) and coordinated by the European Schoolnet. The



country partners are Italy, Cyprus, Greece, Netherlands, and Germany. The DAISy (Dynamic Ambient Intelligent Sociotechnical Systems) research group of HOU realizes society-centred educational and technological research, supports communities of practice, develops online learning platforms, MOOCs, and 3D environments, enables the development of digital and citizenship skills, and promotes inclusion and multiculturalism.

The Greek Free Open Source Software Society (GFOSS) is the national contact point for Greece.

This project has received funding from the European Union's H2020 research and innovation programme – project Scientix 4 (Grant agreement N. 101000063), coordinated by European Schoolnet (EUN).

4. *Hydrobots, STEM for youth (STEM4YOU(th)), <https://www.stem4youth.eu/>*

Enjoy Science, technology, engineering, mathematics. Building an underwater robot. Ocean marine engineering. Engineering for secondary school students. Promotion of STEM education by key scientific challenges and their impact on our life and career perspectives. This challenge introduces students to wonders of underwater robotics. Students are invited to build an underwater robot and a propulsion system, to develop a controller, and investigate weight and buoyancy. This challenge teaches basic skills in ship and submarine design and encourages students to explore naval architecture and marine ocean engineering concepts. The challenge is based on the SeaPearch program developed by MIT professors Thomas Consu and Chris Chrysostomides, this activity is inspired by the book “how to build an underwater robot” by Harry Bohm and Vickie Jensen. The program is currently managed by the association of unmanned vehicle systems international foundation. General objectives include understanding of the principal role of the materials and their properties in engineering, motivation of daily life phenomena, physics concepts (floating), developing inquiry skills and design skills.

Eugenides Foundation is the partner from Greece.

This project has received funding from the European Union's Horizon 2020 Framework Programme for research and innovation, under grant agreement no. 710577.



### 3.2 Erasmus+ projects

The general objective of the Erasmus programs is to support the educational, professional and personal development of teachers and students in STEM education, in Europe and beyond, thereby contributing to education and training incorporating real-authentic world problems that drive to innovation, strengthen skills and motivate active citizenship. The STEM projects aim at designing and developing blended and distance learning environments for teaching prospective science teachers advanced STEM topics. The specific objectives concern the promotion of learning mobility of both teachers and students, non-formal and informal learning mobility and active participation, as well as cooperation, quality, inclusion and equity, creativity and innovation in the field of education and training. Particularly, the specific axes of the projects are:

- the development of innovative digital teaching scenarios on advanced STEM topics
- the development of teaching and learning strategies that promote meaningful use of digital technologies for teaching advanced STEM topics in blended and distance learning environments
- the development of open-access educational platforms where digital teaching material on advanced STEM topics may be shared across Europe in diverse educational, economical, and cultural contexts
- the development of guidelines and recommendations for teaching prospective science teachers advanced STEM topics in online environments.

Erasmus projects with partners from Greece follow.

1. *SEISMO-Lab Framework for Establishing STEAM School Competence Labs*, <https://seismo-lab.ea.gr/>

“SEISMO-Lab will prepare teachers and students to create participatory, inclusive, cross-curricular learning challenges and engage students in projects that will increase their problem-solving skills, creativity, and promotes a learning-by doing attitudes. They will reinforce the application of key (beyond scientific) skills and competences, adopted to the local conditions by employing problem solving skills, handling and studying situations, and participating in meaningful and motivating science inquiry activities on earthquake disaster mitigation. Furthermore, SEIMSO-Labs will create a teacher training program to support teachers in the establishment and implementation of the SEISMO-Labs, including training on



innovative methods such as inquiry-based and experiential learning. SEISMO-Lab supports the creation of Competence Development Labs, developed and run by teachers that will then be able to create “bottom-up” STEAM curricula for their schools, that are enabling students to practice competences and skills that go beyond STEM: learner independence – and interdependence – through collaboration, mentoring, and through providing opportunities for learners to understand and interrogate their place in the world”.

The National Observatory of Athens and Ellinogermaniki Agogi are the partners from Greece.

This project has received funding from the European Union’s ERASMUS+ Programme under agreement No 2021-1-EL01-KA220-000032578.

2. STEM – DIGITALIS, [https://stemdigitalis-project.eu/el/home\\_gr/](https://stemdigitalis-project.eu/el/home_gr/)

STEM Digital Distance Learning in University Teaching (STEM – DIGITALIS) lasted from 01/06/2021 to 31/05/2023 (24 months) and the country partners were Estonia, Germany, Greece, Ireland, the Netherlands. The STEM DIGITALIS project aims at designing and developing blended and distance learning environments for teaching prospective science teachers advanced STEM topics. Particularly, the specific objectives of the project are the:

- Development of innovative digital teaching scenarios on advanced STEM topics.
- Development of teaching and learning strategies that promote meaningful use of digital technologies for teaching advanced STEM topics in blended and distance learning environments.
- Development of an open-access educational platform where digital teaching material on advanced STEM topics may be shared across Europe in diverse educational, economical, and cultural contexts.
- Development of guidelines and recommendations for teaching prospective science teachers advanced STEM topics in online environments.

It is expected that the STEM DIGITALIS results will impact at local, national, and European level by developing digital resources on advanced STEM topics to be used for blended and distance learning in science courses, improving digital competences for both educators and prospective teachers, as well as practical knowledge on how to use digital resources for science-related courses.

The University of Crete is the partner from Greece.



Co-funded by the Erasmus+ Programme of the European Union, grant agreement No 2020-1-EL01-KA226-HE-094691.

3. *STEAMonEDU*, <https://steamonedu.eu/>

“The STEAMonEdu project aims to increase the adoption and impact of STE(A)M education by investing in the community of stakeholders and the professional development of educators. As a result of research and creative techniques that will be instrumental among the members of the community, the STE(A)M education framework will be produced, which will include competences, policies, methodologies, educational objects, etc”.

DAISSy the Computer Technology Institute and Press “Diophantus” and the Regional Directorate of Primary and Secondary Education in Western Greece are the partners from Greece.

Co-funded by the Erasmus+ Programme of the European Union, grant agreement 612911-EPP-1-2019-1-EL-EPPKA3-PI-FORWARD.

4. *Going the Distance*, <https://eduact.org/erasmus-capacity-building-of-stem-tutors-for-providing-distance-learning-going-the-distance-el/>

“This two-year KA2 project aims at making digital education technologies accessible to all offering open access to a wealth of information, education and training resources while also offering guidance on how to evaluate and make efficient use of them even in times of crisis such as the COVID – 19 pandemic. It has been recognized by the partnership that in STEM Fields such as educational robotics the transition from physical to virtual has been particularly difficult. Therefore, in accordance with the new requirements of the VET sector and EC’s Digital Education and Action Plan (2021-2027) this project has been designed in order to: a) Identify the tutors’ specific needs during the COVID-19 period, b) Distinguish from other free relevant digital tools that are of poor quality, c) Navigate them on how to deal with the social repercussions identified mainly on youngsters because of the lack of actual contact, d) Prepare a new training curriculum for tutors and develop innovative digital support materials, e) Train the tutors on how to make effective use of the above, assess the educational content and receive feedback, f) Create an open distance learning platform with online courses, webinars, tutorials, evaluation based on electronic badges, etc”.

Eduact is the partner from Greece.



Co-funded by the Erasmus+ project Form ID: KA226-B868EC58.

5. *Maker schools: Enhancing Student Creativity and STEM Engagement by Integrating 3D Design and Programming into Secondary School Learning* <http://makers-project.eu/>

STEM knowledge and skills are regarded as key to Europe's competitiveness and its ability to address societal challenges. Currently, there are not enough STEM graduates to meet the demand for STEM professionals. It is therefore necessary to increase the proportion of students interested in, and well prepared for, STEM studies and career. STEM needs to respond to the latest changes in technology and industry demands. At the same time, it needs to become more inclusive, engaging and attractive to students. 3D technology, especially when combined with Programming, can greatly enrich current STEM initiatives. It develops students' creativity, innovation and problem-solving skills. It sensitizes students to the link between STEM and the production process. It also fares very well in terms of student engagement. 3D leads to results that students can literally touch and see, which is satisfying and can make STEM activities more agreeable to otherwise reluctant learners. Finally, it is one of the best technologies for seamlessly integrating STEM into Arts & Design.

The project's overall objective is to enable the application of 3D design and printing in STEM education in secondary schools:

- -Provide teachers and students with learning/teaching resources on 3D design and printing
- -Provide teachers and students with learning/teaching resources on the application of the Python programming language in 3D design and creative explorations of 3D models
- -Equip teachers with methodological and didactic guidance for the design and delivery of STEM education in the 3D technology area.

The Directorate of Secondary Education, Chania and the Technical University of Cete are the partners from Greece.

Co-funded by the Erasmus+ Programme of the European Union, Ref. no. 2020-1-BG01-KA201-079274.

6. *MiniOpenLabsSTEM*, <https://miniopenlabstem.com/>





The main goal of the project is to set-up and test an open community and hands-on approach to Sustainable Development and STEM Education of children (6-12 years old), comprising:

- MiniOpenLabs: the MiniOpenLabs are small laboratories, open to the local community, where children, under the guidance of teachers or other educators (including parents), may engage in STEM-based projects on sustainable development.
- Activity Book: this Book will contain a set of STEM-based projects on sustainable development that may be carried out in the MiniOpenLabs.
- Workshops: includes creating guidelines and running different events to capacitate teachers on the MiniOpenLabs approach and to involve the local community on STEM education activities.

The University of Western Macedonia and Anatolia Education Group are the partners from Greece.

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

7.EUMentorSTEM, <https://www.unibo.it/en/international/european-projects-of-education-and-training/eumentorstem-creation-of-a-european-e-platform-of-mentoring-and-coaching-for-promoting-migrant-women-in-science-technology-engineering-and-mathematics>

“EUMentorSTEM seeks to foster the performance, learning and development of women with migrant background to consolidate their career in STEM (Science, Technology, Engineering and Mathematics) jobs in Europe (as paid employees or as entrepreneurs). The project aims at developing and testing innovative materials on mentoring and coaching (M&C) targeting migrant women with a STEM background and the professionals working with them (career advisors, educators, recruiters, counsellors, etc.). The learning and teaching materials will be shared in an online European knowledge hub in all partner languages. The project is designed to take into account three critical intersections in Europe. First, the increasing influx of migrants. Second, the gender gap in STEM-related jobs. Third, the double disadvantage faced by highly-skilled migrant women in the labour markets”.

The Greek women engineering association is the partner from Greece.

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



8. Fun & Engaging STEM Activities For Tomorrow's World, <https://www.zarifeios.gr/ekpaideutika-programmata-menou/eurwpaika-programmata-menu/245-erasmus/fun-engaging-stem-activities-for-tomorrow-s-world.html>

The core of the project is that Maths and science should be taught in a more enjoyable way. We would like to motivate pupils to learn "Science" through the introduction of the world around them. It is focused on increasing and making more pleasant and enjoyable the learning of Maths and Sciences. Science and Maths contribute to develop in the students a logical-deductive mind and planning skills (competences) which is one of the main competences in active citizenship. Moreover, sciences and Maths help abstraction processes from "doing" to "thinking" so enabling students, especially foreign students or students with special needs, to be integrated in the activities. The project idea is student-centered and focused, and the position of the project aims to strengthen the academic success of the institutions. With fun mathematics teaching and science experiments, students will be motivated to learn more, and teachers will be able to teach skills and competencies with different teaching environments. They will do so through the exchange of experiences and international cooperation. Many of our disadvantaged students will take part in project activities and these students will reach equal and fair learning environments and contribute to their being active European citizens. The small eco-friendly works contributing a sustainable Green lifestyle to provide for a safe, just global community. In addition, it will develop and enrich pupils' understanding of the concept of "small changes in their daily lives" in an environmentally threatened world. The teaching and learning environments of our partner schools will improve, the cooperation between institutions will be strengthened, student academic skills will increase, and the students will develop thinking and action skills for the prevention and resolution of environmental problems. Moreover, the workshops and trainings will address problems of development of key competences; entrepreneurship; social, civil and intercultural competences; counteracting aggression and violence among students. It will strengthen the feeling of belonging to the school culture, fight against dropping out of school. The partners will include as a goal of international cooperation of kids - social and cultural awareness and problem solving between them, their roles in the group work (leader, follower, thinker, doer...) Kids cooperation as a bully prevention, social skills on international level. To extend students' communicative, social, problem-solving skills on international level and this way help them become "European citizens" realizing and pursuing their own culture.

The model primary school of Alexandroupolis is the partner from Greece.



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

### 3.3 e-Twinning programs, seminars, and summer schools

Beyond the HORIZON 2020 and Erasmus+ projects, Greek stakeholders organize and participate in eTwinning programs, seminars, and summer schools. Indicative programs follow. The six seminars presented are organized under Erasmus projects.

1. *STEM Education Organization*, <https://stem.edu.gr/en/stem-masterclass-educators-erasmus/>

The International Summer School of Educational Robotics is aimed at teachers of all levels, from countries all over the world. Participating teachers attend presentations and workshops facilitated by experienced educators with multiple participations and achievements in World Robot Olympiad. The school will be held in English, while at the same time interpretation in Greek will be available upon request.

2. *S.T.E.M. Robotics Education*, <https://www.stemrobotics.gr/erasmus-teachers-training>

The Scientific Educational Association for the Advancement of Science, Technology, Mathematics and Robotics “S.T.E.M. Robotics Academy”, is a Nonprofit Educational Organization, based in Larisa-central Greece. This team includes teachers, researchers, scientists, and professionals with interest in STEM (Science, Technology, Engineering, Mathematics) and Educational Robotics. At STEM Robotics Academy next generation of scientists, engineers, designers, innovative manufacturers and entrepreneurs are trained. The students are trained in solving complex problems by using innovative teaching methods, state-of-the-art technology and through STEM field sciences.

3. *DOREA Educational Institute*, <https://dorea.org/erasmuscourses/promoting-stem-education/>

DOREA Educational Institute is a non-profit organisation established in 2012 with the main headquarters in Limassol, Cyprus. The training course focuses on enriching the STEAM curriculum through innovative activities for students, available learning and teaching resources as well as enriching educators’ skills in engaging and motivating their students. The course also explores the need to involve the local community and organisations. The course is ideal for educators who teach STEAM and want to further enrich their lessons. The training as well could be adapted for beginners who would like to implement the STEAM curriculum in their schools.



4. *e-Nable Greece*, <https://enabling.gr/en/erasmus-courses/>

The aim is to share our knowledge and technology of 3D Printing, STEM materials, sustainability etc. to all our European colleagues. Structured Erasmus+ courses and workshops are developed which cover different section of the basic framework. The seminars are always customized, depending the professional background and needs of the trainees.

5. *Platon Erasmus+ KA1*, <https://platon.edu.gr/europeanprojects/erasmuska1/>

Erasmus+ KA1, Training Courses. The Erasmus+ KA1 action offers teachers opportunities to improve their skills by participating in training courses in organizations in other countries. Platon schools provide a range of such training courses on topics such as intercultural education, digital skills, educational robotics, STEM teaching, social skills and game-based learning. Every year groups of teachers from all over Europe are hosted for a period of time in Katerini and participate in the training courses of our school.

6. *The STEM abilities in the 21st century, Serres*, <https://erasmus2020.splet.arnes.si/ltt-c1-the-stem-abilities-in-the-21st-century-greece/>

The project is not just meant for students and teachers but for the wider community and the objectives may differ from one group to another. Students' objectives: the most important objective is to increase students' interest in science, technology, engineering and mathematics; to feel good and have enough self-esteem to work with others in a project (project based learning) and communicate with them in English; to develop a project based learning awareness; to develop or improve in students the skills such as creativity and intellectual curiosity, knowledge and media literacy, critical thinking, cooperative work, problem solving; to learn how to use different ICT technologies and programs; to encourage girls to gain self-confidence in scientific learning, engineering and team work; to prepare them (language use and speaking confidence, culture etc.) for the exchange in other countries. Teachers' objectives: teachers that don't have knowledge in STEM approach to learn about it, with the help of other partners, and to be confident to use it in their working and living environment; a project process in which teachers (that don't have engineering in their classical curriculum) develop their skills related to the integration of engineering cycle into their course; to share good practices; to create a positive school atmosphere that would contribute to students' logical thinking, to the development of their creativity in engineering and develop their self-esteem; to learn about other cultures and share the experience with other colleagues to motivate them and to promote Erasmus+; to improve speaking confidence in using foreign languages in



communication teachers; – to organize the activities for students, staff and local community; to promote the project on social media and local news. The objectives for parents (guardians): to get them involved in organized project activities; for them to take the part in offering their homes to the foreign students; to help the school with preparing traditional food and cultural events. The objectives for local community: to include it in some project activities; to promote it through project activities and socializing with locals and local organization.

7. National Organization for supporting eTwinning actions, [www.etwinning.gr/news/stem/1197-etwinning-stem-4-0-500](http://www.etwinning.gr/news/stem/1197-etwinning-stem-4-0-500)

With the successful actions of eTwinning STEM 1.0, STEM 2.0 and STEM 3.0 almost 800 schools were equipped with robotics kits and 3d printers, but also supported teachers in the implementation of STEM - eTwinning projects and with their training. The National Support Organization of the eTwinning action plans the continuation of the action with STEM 4.0, this time aiming to promote inclusive education and diversity! Beneficiary schools: 500 Schools of Vocational Education, SDE, Minorities, Prisons, Hard-to-reach Areas, Special education settings.

### 3.4 Summary

STEM education in Greece seems to be applied through projects and seminars.

Four HORIZON 2020 projects have been recorded. Two of them mainly refer to robotics as a part of STEM education. PAFSE seems to follow the integrated STEM approach. Scientix seems to be a “connection point” among similar projects.

Seven Erasmus+ projects were found dealing with various STEM topics. Universities, public and private primary and secondary schools participate from Greece. Most of the projects concern specific STEM fields.

Six seminars coming from Erasmus+ projects were also recorded. They address to students, teachers, and parents. Mainly private education stakeholders participate to the above activities.

Finally, the National Organization for supporting eTwinning actions supports a series of STEM related eTwinning initiatives.



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## 4 Research results from Greek researchers

Research results related to STEM coming from Greek researchers working mainly in Greece are recorded. These come from the peer-reviewed conferences of the two major scientific associations, namely the “Hellenic Scientific Association of Information & Communication Technologies in Education” and the “Association for Science Education and Technology”. Indicative research results are also gathered from international scientific journals and volumes.

### 4.1 Conference papers

4.1.1 Hellenic Scientific Association of Information & Communication Technologies in Education ([www.etpe.gr](http://www.etpe.gr))

**7<sup>th</sup> National Greek Conference “Integration and use of ICT in educational process”, Patra, 16/09/2022 – 18/09/2022, ISSN: 2529-0924, ISBN: 978-618-83186-7-0**

1. Christodoulou, E., & Polatoglou, H. (2022). Educational robotics as a medium of creativity development in primary education within STEAM context.

This work explores the acquisition of 21st century skills during the involvement in STEAM activities to primary education students. The teaching interventions based on the theory of constructionism according to the principles formulated by Seymour Papert. The methodological framework of the Four Pi's of Creative Learning by Mitchel Resnick was adopted and the Educational Robotics package LEGO® Education WeDo 2.0 Core Set was used. The participants created original constructions, which were evaluated by a group of experts through the Consensual Assessment Technique. The outcomes indicated the effect on creativity caused by the involvement of students in STEAM Education activities Robotics.

2. Gkoltsiou, A., Karapetsa, V., Kokkinou, X., Mplanas, S., & Sofianopoulou, H. (2022). The Skills Labs in digital Bloom taxonomy: Action research with blended learning.

The article presents the implementation of the Skills Labs, an innovation that was recently introduced in the Greek curriculum of Primary and Secondary education and aims to cultivate students' skills. The activities are developed in a digital learning environment with co-teaching and blended learning, according to Bloom's digital taxonomy, as action research. The evaluation of the action was done by investigating the opinions of the students, with student self-evaluation rubrics and portfolios and





structured observation by the participating teachers. Students cultivated life skills, essential learning skills of the 21st century and STEM skills.

**12<sup>th</sup> National Greek and International Conference “ICT in education”, Florina (online), 14/05/2021- 16/05/2021, ISSN: 2529-0916, ISBN: 978-618-83186-5-63.**

3. Sismani, V., & Hadjileontiadou, S. (2021). Cultivating spatial thinking as a cross-cutting thread in STEM domains. Implications for the utilization of the educational robot construction procedure.

This work proposes the use of the educational robot construction procedure towards the cultivation of spatial thinking as a cross-cutting thread in STEM education. An empirical case on the construction procedure of a robot, by a pair of primary school students using WeDo 2.0 blocks, is presented and spatialized in terms of construction actions and relevant argumentation. The proposed work contributes at the metacognitive level to promote possible far transfer of spatial thinking in STEM domains.

4. Ioannidis, S., Velentza, A. M., Lefkos, I., & Fachantidis, N. (2021). Students’ perceptions about the use of social assistance robots in STEM.

This research proposes the use of social assistance robots as a teacher assistant for students 13-17 years old. An intervention related to STEM teaching was designed and developed by a teacher with an expertise in STEM in a real school classroom. The teacher used the robotic assistant STIMEY as a teaching facilitator, which interacted with the students. The posttests indicated that the students evaluate the use of social assistance robots in STEM learning positively. Specifically, they referred that using robots, such as STIMEY robot, in STEM topics contribute to engagement, motivation and better understanding.

5. Arvanitakis, G., Bratitsis, Th., Xeferis, S., & Palaigeorgiou, G. (2021). Methodology of support design thinking through design cards in primary education.

This study proposes an approach to support design thinking in the context of STEAM – educational robotics, for high grade students at the Primary School. The approach is based on 40 design cards, which aim at students' supported exploration of problems, needs, opportunities and ideas in vaguely defined design problems. Application of the approach in 6 sessions with 31 students participating in an educational robotics group is presented, as well as results regarding the creativity and innovation of the ideas



produced. The students argued that the proposed design methodology allowed them to explore the problem in an unexpected, creative and productive way.

6. Tsapara, M., Arkouli, A., Arhonti, V., Papadogkona, K., & Rentzepe, K. (2021). The smart school: creative solution of an environmental problem, used the Makey Invention Kit.

This work concerns an educational activity implemented in kindergarten. The specific goal was the development of creative thinking through the environmental problem solving that concerns the waste of water and energy in students' everyday life at school. Combining environmental education with STEAM education, skills related to creativity, critical thinking, communication and collaboration were cultivated within an inquiry learning framework. Wanting to connect the real and the digital world, children from each school created a mock-up of their school, used the Makey Invention Kit, created tangible interfaces incorporating smart functions that could help save energy and water, recorded sounds and audio messages, while through the Scratch educational programming environment, they gave simple commands. Through the educational activity, they became aware of the environment they live in and formed attitudes, taking active action and participation to improve and protect it.

7. Iliadis, P., & Fragkoulis, G. (2021). Braitenberg vehicles as interdisciplinary STEAM approach in biology lesson.

This article presents an interdisciplinary approach, through STEAM, to the teaching of the biology course of the 1st grade of secondary education in Greece, which was the subject of a laboratory session for teachers and researchers in the context of the 12<sup>th</sup> National Greek/International Conference "ICT in education". The approach is based on the simulation of the nervous system and the reactions of living beings to external stimuli of their environment, using Braitenberg vehicles. With the simple construction and simple programming of these vehicles the authors get a multitude of different behaviors.

8. Arvaniti, V., Kalampokis, I., Koliakou, I., Mastrogianni, A., Bratitsis, Th. (2021). Green education for a sustainable future.

Green education has a decisive role in raising students' awareness of environmental issues and in shaping correct attitudes and behaviors that can contribute to a sustainable future. Programs such as GREEN EDU - Green education for a sustainable future (GREEN EDU- Green Education for a Sustainable future -PROJ. № 2019-1-PL01- KA201- 065695) can contribute significantly in this direction. Green Edu is funded by the European Union's Erasmus+ program and aims to encourage students to engage in

**Project 2022-1-BG01-KA220-HED-000088567 Green STEM model for teachers education**

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innovative fields of science and help them acquire knowledge and develop skills that will prepare them to become responsible citizens of the 21st century. This paper presents the goals, the pedagogical approach and briefly the activities of GREEN EDU, as well as examples of the application of educational scenarios in the online classroom of B and C Primary.

9. Mpentevinou, M. A., Lefkos, I., & Fachantidis, N. (2021). Exploring the contributions of educational robotics activities in perception and understanding of students regarding force and moment.

This work investigates the possible change that occurred after the participation of High School students in Educational Robotics activities included in a teaching series that concerned Engineering phenomena, in the views and understanding of the concepts of force and moment, by the students. Student responses were collected through questionnaires before and after the intervention, while a limited number of interviews were also conducted. The results support that the students not only improved their knowledge of force and torque, but also became aware of this improvement.

10. Gaki, O., & Jimoyiannis, A. (2021). Study programming in Scratch Jr to solve simple problem skills of preschool children.

This paper presents the design and implementation of a sequence of activities to solve simple problems of preschool content through programming in Scratch Jr. The research is a case study, in which 18 children of a public kindergarten participated. The research data was derived from the analysis of the digital projects of each group and the opinions-ideas of the children recorded through short semi-structured interviews, during the presentation of their projects to the researcher. The analysis highlighted the achievements and difficulties of the young students, who became familiar with the programming environment, developed skills to apply basic programming commands and applied pre-curricular concepts (position, direction, path) to simple programming problems. The paper proposes the inclusion of programming in kindergarten with aimed at the cognitive development, the cultivation of skills and the development of children's creative expression.

11. Papazoglou, Th. & Karagiannidis, H. (2021). Initial perception of students with autism regarding concepts of educational robotics and programming.

The aim of this article is to present the initial perceptions regarding concepts of Educational Robotics and Programming, of 14 students with autism spectrum disorder who were enrolled in the



Primary School. Research data were collected through assessment sheets and the results seem to enrich the existing literature.

12. Papamargariti, A., & Dimitrakopoulou, A. (2021). Review of ways and tools that support the teaching process of educational robotics activities.

This literature review studied the design of educational robotics activities in terms of the learning support provided to students. The aim was to clarify the ways and tools that support the teaching process, considering the factor of social interaction between students. A systematic search resulted to 7 literature reviews and 15 research articles in journals and conference proceedings. The outcomes indicated that the general pedagogical design is consistent with the constructivist and constructionist view of learning, but the majority of the researchers of the included studies do not use specific, targeted tools to support learning process and they do not organize a structured way of student interaction.

***6<sup>th</sup> National Greek Conference “Integration and use of ICT in educational process”, Athens  
18/10/2019 - 20/10/2019, ISSN: 2529-0924 ISBN: 978-618-83186-4-9***

13. Antonopoulou, K., Lavidas, K. & Zaharos, K. (2019). Programming routes by Ozobot bit in preschool education.

This article presents the findings of a research regarding the utilization of the robotic platform Ozobot bit, which was carried out in March 2018 in a public Kindergarten of Patras. The aim of the research was to investigate whether children are able to recognize the colors of the direction codes, which represent the movement of the Ozobot bit robot, as well as to be able to apply them to problems of direction and orientation. To achieve the objectives, the authors conducted semi-structured interviews implementing an educational scenario. Ten children participated in the study and were asked to identify and use three color codes in order to move the robot from the starting position to the final position through a problem-solving process. The results of the research showed that children are able to recognize the colors that correspond to direction codes and through appropriate guidance can apply them to move the robot.

14. Papadakis, S. (2019). Evaluation of an educational intervention for teaching programming and STEM concepts through the creation of a weather forecasting smart mobile application.



This paper presents an educational practice that combines coding with learning STEM concepts through the creation of a weather forecasting smart mobile application. The practice was implemented for students of the 2nd grade of a General High School as part of the Research Work course and its results are considered encouraging as the students were involved in authentic activities related to the scientific fields of STEM, contributing to the improvement of their knowledge and attitude in subjects of Technology, of Mathematics and Programming.

15. Papadopoulou, F., & Psycharis, S. (2019). Exploring computational thinking and STEM epistemology through machine learning: learning through examples using the platform of Machine Learning for Kids.

This paper is an attempt to connect machine learning with Computational Thinking and STEM Epistemology. Specifically, it presents a machine learning platform, where the participants are involved in the creation of a machine learning system by programming in Scratch, with an emphasis of Physical Computing. The outcomes highlighted the developing dimensions of Computational Thinking while participants create machine learning activities and develop "expert systems".

16. Polyzois, G., Kerastas, V., & Mantzios, H. (2019). A case study of design STEM lessons: the spring.

This work concerns an educational intervention of four sessions based on STEM teaching. The specific subject is entitled "Mass Measurements - The Diagrams" and is taught in physics lesson of the first grade of junior high school. Firstly, the students were taught the Cartesian coordinates and the creation of graphs during mathematics. Secondly, in the computer lab of their school, they grouped each other and "calculated" the unknown mass of an object through the gradual creation of the corresponding diagram using a simulation, created with Geogebra software. Thirdly, in the science laboratory, the students collaborated and constructed the experimental set-up, performed the measurements, drew the calibration graph of each group's spring, calculated the mass of their physics book and discussed issues related to both the practical nature of the experiment and the theoretical of processing and interpretation.

17. Dorouka, P., Zaranis, N., Kalogiannakis, M., & Papadakis, S. (2019). Teaching elements of Nanotechnology through digital technologies in early childhood.



The aim of the study is to examine the impact of STEM education in early childhood. Specifically, the study examines whether tablet-based teaching is more effective in learning elements of Nanotechnology - a cutting-edge technology - from young children compared to computer-based teaching, as well as traditional methods of teaching.

***9<sup>th</sup> National Greek Conference of Informatics education, Thessaloniki 19/10/2018 - 21/10/2018, ISSN: 2529-0908 ISBN: 978-618-83186-1-8***

18. Stati, F., Kaltekis, G., Fesakis, G., & Dimitrakopoulou A., (2018). Goldberg machines in educational robotics: teachers' perceptions.

This work proposes an educational approach which uses Rube Goldberg machines to give an authentic and entertaining character to Educational Robotics. To explore the views of teachers for the proposed approach, a fast-paced training program was designed and applied to postgraduate students of science teaching. The program includes a short theoretical introduction to the teaching approach and application of two indicative teaching scenarios with corresponding Rube Goldberg machines implemented with the LEGO-NXT Educational Robotics collection. The paper presents the teaching approach, the training program and its results.

***11<sup>th</sup> National Greek and international Conference "ICT in Education" of Informatics education, Thessaloniki 19/10/2018 - 21/10/2018, ISSN: 2529-0908 ISBN: 978-618-83186-1-8***

19. Mastori, M., Pezarou, P., Samoutian, M., & Partaliou, T. (2018). Introduction in educational robotics through eTwinning STEM action.

This paper refers to the eTwinning project "STEM tale and BeeBot Challenge for Little Learners", which was designed and implemented, in the context of the call for expression of interest by the National eTwinning Service for participation in the action with STEM oriented projects in Primary and Secondary Education schools. Teaching proposals for introducing Educational Robotics and implementing STEM activities are presented, with the aim of developing the personal skills of each child within a favorable learning environment. Through this collaborative project, with the contribution of a well-known and popular fairy tale, and a robotic device, an attempt is made to approach basic concepts related to the learning areas of Natural Sciences, Mathematics, Engineering, Art and Language by preschool students 7 Kindergartens: 5 from Greece, 1 from Cyprus, and 1 from Slovakia.



20. Panagiotou, E., & Diamantidis, D. (2018). Narration as educational strategy in STE(A)M activities in order to motivate students: a case study.

The study focuses on the use of storytelling as an educational method in a STEAM environment, where students mobilize their interest in social issues, such as people with disabilities, and create their own robots, utilizing STEM sciences and creativity (Arts), trying to contribute to the above issues. The research leading to these results was funded by her program European Union Horizon 2020, under contract GA 665972.: project “Educational Robotics For STEM: ER4STEM”.

21. Tsiastoudis, D., & Polatoglou, H. (2018). Introduction to STEAM education using open technologies and virtual experiment.

The purpose of this paper is to present a case study where an action research is conducted for the development of a methodology as part of an overall design, suitable for the introduction of STEAM courses using open technologies in a non-formal education environment. In particular, we developed an interdisciplinary educational process based on discovery learning, the principles of learning communities and differentiated teaching. An application of the methodology is also presented, in a didactic intervention that uses the Arduino platform and aims to solve an authentic contemporary problem. We describe the objectives set, the method of investigating interests, the methodology and implementation framework, the difficulties we faced, and the necessary adjustments. Finally, although the research results support this framework of non-formal education, we describe the intentions of continuing the research in a wider student population to draw safer conclusions.

22. Ioannou, M., Bratitsis, Th., & Tsoolpani, I. (2018). Representations of velocity in Sphero Edu environment for preschool children.

This paper describes the design and evaluation of representations of velocity for preschool children using the Sphero Edu application, as a continuation of the authors' previous research on teaching this concept to kindergarten students using the Sphero SPRK. The representations referred to animals, vehicles, balls and numbers.

23.Theodoropoulou, I., Katapodi, A. M., Giahali, Th., Lavidas, K., & Komis, V. (2018). Outcomes and prospects from the utilization of educational robotics in greek school.





This systematic review focus on teaching interventions using robotic devices with the aim of presenting: a) a synthesis of the available results on the use and benefits of educational robotics and b) a synthesis of the research perspectives of educational utilization of robots. Following an online search, 54 relevant articles of Greek research approaches published in conference proceedings were identified and their content was analyzed according to the level of education (preschool, primary, secondary). According to the results of the research, educational robotics seems to support the development of 21st century skills and can be used in the teaching of various subjects. The conclusions of this research can be used as a reference point for future research and provide useful information to researchers and educators.

24. Stamou, A. & Manolopoulos, I. (2018). STEAM education in practice: The RoboPathFinder project.

This paper suggests a novel challenge based on educational methodology for STEAM education following the cooperative and learner-centered educational approaches. The aim of the study is to promote creative thinking and effective collaboration. The RoboPathFinder project is presented, as it was implemented by secondary education students through the guidance of their coaches, following the proposed methodology. The RoboPathFinder concept has been inspired by the Mars Pathfinder robotic spacecraft, being created with open-source software, an Arduino board, ultrasonic sensors, gear motors and a solar battery.

***5th National Greek Conference "Integration and use of ICT in educational process", Athens  
21/04/2017 - 23/04/2017, ISSN: 2529-0924 ISBN: 978-618-83186-0-1***

25. Tsiastoudis, D., & Polatoglou, M., H. (2017). Arduino as a pedagogical tool for STEM education to students with hearing disabilities.

This paper presents one of the overlapping cycles of an action research that was carried out in an educational process of STEM objects that operated in the Department of Physics of the Aristotle University of Thessaloniki regarding the inclusion of students with disabilities. Specifically, Arduino was used in the laboratory in a series of educational interventions in STEM subjects ("Robo-Wednesday"), based on constructivism, learning communities and differentiated teaching. A heterogeneous group of high school students, including three students with deafness participated in the intervention. This paper presents the second of the six interventions that were developed, its limitations, the essential adaptations, as well as



the benefits in the acquisition of cross-curricular skills, technological literacy and the enrichment of Greek sign language in order to include students with a hearing loss.

26. Stayropoulos, P., & Ekonomidis, S. (2017). Study of the effect of an educational digital scenario based on STEM in educational process.

This work describes a digital teaching scenario based on a STEM approach that is posted in the Mechanic Engineering subcommunity of the Easy Java Simulations community, ODS-ISE (Open Discovery Space–Inspiring Science Education) platform. Two open-source educational software have been used to teach the “Car Catalytic Converter” course. The scenario was developed in two laboratories in real conditions. The implementation and evaluation of the scenario took place at the beginning of this school year (2016-2017), with a "selection" sample of 40 Mechanical Engineering teachers of Secondary Vocational Education. The outcomes indicated that the pilot application of the scenario promotes and improves the educational process and the participants were very positive to integrate the scenarios in their educational process and to collaborate with other field teachers.

27. Kyriakopoulos. N. (2017). Using STEM in horizontal shot study.

This study followed STEM (Science, Technology, Engineering, Mathematics) process in teaching the phenomenon of horizontal shooting to 37 students of the 2nd grade of the General High School during a physics lesson. The educational scenario based on the principles of discovery learning where students working in groups tried to discover the laws that govern the phenomenon of horizontal shooting. The paper then analyzes the teaching scenario (lesson plan, worksheet and evaluation sheet) as well as the way in which the STEM methodology was integrated into the teaching practice.

28. Paliouras, A. & Psycharis, S. (2017). A teaching recommendation for programming lesson based on STEM methodology in high school.

The purpose of this study was to evaluate the outcomes of high school students in computer programming using STEM method. Specifically, the researchers used the Arduino system in relation to the use of Pseudolanguage as well as students’ attitudes towards STEM. The teaching intervention proposed nine complete worksheets using the Arduino microcontroller and the Ardublock programming environment. The 2nd grade General High School course is evaluated via written exams in the programming environment of Pseudolanguage, thus the researchers incorporated Pseudolanguage into



their proposal, although in the 1st grade elective course "Computer Applications" it can be applied without Pseudolanguage.

29. Ioannou, M., & Bratitsis, Th. (2017). A content for STE(A)M teaching in kindergarten: an initial exploration.

This paper describes the theoretical framework on which STE(A)M education is based and provides a first overview of the research that has been implemented in the context of kindergarten.

30. Delistavrou K., Kameas A. (2017). Exploring Ubiquitous and Mobile Computing to Leverage STEM Education: A Second Educational Scenario.

Our everyday life is affected by technologies like Mobile Computing, Ubiquitous Computing and the Internet of Things. Ongoing research at the Hellenic Open University aims to leverage STEM education by providing an educational framework that exploits such technologies. For this reason, a novel educational methodology is being developed. It is going to include a set of educational scenarios backed by a platform of proper software and hardware configurations. Development of the methodology continues with a second pilot scenario. Its rationale, steps and expected results are described and discussed here. The next steps of the research are defined.

31. Kotsifakos, D., & Douligeris, H. (2017). Theoretical, historical and ontological prerequisites for effective STEM teaching in Technical Education.

In line with teaching guidelines of the Ministry of Education, a two-hour STEM (Science, Technology, Engineering and Mathematics) teaching is provided in the 1st grade of Vocational High Schools (EPAL). This study reviewed dimensions of theoretical, historical and ontological prerequisites in order for the teacher to be able to implement effective STEM teaching for Technical Vocational Education (VET) students. The degrees of difficulty are analyzed based on teachers' priorities of teaching and learning process. Finally, the cognitive framework that should be structured in the context of online collaborative technology in order to achieve the optimal adaptation to the professional fields of the specialties that the TEE students will choose.

32. Iatrou, P. (2017). Intersubjective approximation of the linear function.

This work was created as part of a postgraduate program and is an example of the application of STEM (Science, technology, engineering) in secondary education with the computational experiment



method. Our proposal presents a didactic approach to the linear function applying connections between mathematics, physics, engineering and informatics as well as its application to everyday life problems. The multifaceted treatment of a cognitive object, the active participation of students in all steps of teaching using the computational way of thinking and the choice of activities of general interest, strengthen the interest of students, connect the concepts, and improve the effectiveness of our intervention.

33. Mastorodimos, D., & Psycharis, S. (2017). Training Workshop: Familiarization with Easy Java Simulations software and Arduino type microcontroller to create STEM simulations.

This work concerns a laboratory presentation which uses the Easy Java Simulations software and the Arduino type microcontroller, in order to develop simple computer models simulations. The software and hardware combination can benefit students through training in Java programming and coding, as well as in controlling Arduino-type microcontrollers, in order to strengthen computational thinking and develop skills. Moreover, teachers can create their own teaching scenarios for simulations by making additions or modifications they choose. In the presentation, Easy Java Simulations will be used, connecting to the Arduino type microcontroller and performing three activities in Science, Technology, Engineering and Mathematics.



4.1.2 Association for Science Education and Technology (<http://www.enepnet.gr>)

***13<sup>th</sup> National Greek conference of physics education and new technologies in education. new trends and research in science learning, teaching and technologies, 2023, ISBN: 978-618-82063-2-8***

34. Papagiannopoulou, Th., & Vaiopoulou, J., & Stamovlasis, D. (2023). Elementary teachers' readiness to implement STEM programs.

The interdisciplinary STEM approach aims to equip students with real-world problem-solving skills to cope with future changes. In the present study, the attitude and readiness of Primary Education teachers to implement it were investigated and a validated questionnaire was used to collect data from 348 educators. From the analysis of the effects of individual differences on the dimensions under investigation, a statistically significant relationship was observed between the educational background, age, years of teaching experience as well as the educational branch in terms of teachers' readiness, while emotional readiness and self-efficacy can predict their attitude.

35. Koumara, A., & Polatoglou, H. (2023). Teaching physics concepts and develop soft skills during the preparation of secondary school students in a STEM competition.

In the present work the teaching of science concepts and the developed soft skills, during the preparation of 14 secondary students to a robotics competition, are presented. Students had to design and implement their own robot. They worked in five groups for six months. They comprehended the concepts of "inertia" and "speed", while developing creativity, communication, collaboration, and critical thinking skills. The skills were measured through a developed rubric. It was pointed out that all groups developed their soft skills, at a different level. Science concepts were studied through discourse analysis from students' interviews.

36. Tsihouridis, Ch., Mitrakas, N., Karavasilis, A., & Vavougios, D. (2023). Interdisciplinary approach of teaching physical pendulum using BBC Micro:bit.

In this research, the degree of ease of use and effectiveness of the Micro:bit is investigated, during the interdisciplinary approach of teaching and introducing students to the concept of moment of inertia using the physical pendulum. 25 junior high school students participated in the research, who cooperatively built a physical pendulum and through worksheets collected and processed the data of their measurements. The method followed included the use of a pre and posttest questionnaire as well as a



focus group discussion. The results highlight the feasibility of using the micro-controller, enhancing the learning outcomes of the interdisciplinary teaching approach as well as the motivation for participation in the educational process.

37. Kritikos, G., & Matsigkos, A. (2023). From rotational to linear reciprocating motion: Lego Mindstorms EV3 robotic constructions.

In High School Physics, both rotational and reciprocating motion are taught, but not the transformation of rotational into reciprocating motion, although this transformation is used in many mechanical applications. With the present work, we attempt to investigate the contribution of the creation of robotic constructions with the aim of highlighting the transformation from rotary to linear reciprocating motion. The research is a case study in children of the 2nd grade of General High School. Based on the research design, children are asked to build devices that implement this motion transformation, using the Lego Mindstorms EV3 educational robotics package.

38. Ioannou, M., & Ravanis, K. (2023). Melting in kindergarten through a steam project about the water cycle.

Thermal phenomena in Early Childhood Education are of great interest as children form concepts, ideas, and construct models of the world around them. This paper presents the first phase of a STEAM program for the water cycle. In particular, the activities and the preliminary results from the activities concerning the melting and melting of the ice are presented. Finally, it seems that the STEAM approach, through the utilization of the Engineering Design Process, for the introduction of activities on thermal phenomena in the early childhood had positive results.

39. Ioannou, M., & Theodoraki, x. (2023). Spark: indoor & outdoor steam activities in early childhood education.

In the last years, STEAM Education is gradually increased in kindergarten and in Early Childhood Education, in general. The present paper presents the process of designing and developing a set of STEAM activities for Early Childhood Education through the program SPARK. Specifically, the paper presents the indoor and outdoor STEAM activities that follow the Engineering Design Process, a problem-solving process. In addition, the overall actions of the project, the stages of the material development, the preliminary results from the pilot testing and the prospects are presented.



40. Topoliati, M., & Plakitsi, A. (2023). Sustainable kindergarten studies earthquakes through the exploitation of educational robotics and its participation in the seismo-lab network.

This research focuses on the application of educational intervention and concerns the study of earthquakes by kindergarten students in the context of their participation in the Erasmus+ project: “Seismo-Lab”. Action research is carried out during the planning and implementation phase of the program, which simultaneously focuses on the selective approach of sustainable education goals. STEAM education and robotics are exploited as methodological tools. The research framework is completed with the process of the overall evaluation and dissemination of the learning results by the students themselves and the teacher.

41. Kaisaridi, P., Pappas, E., Smyrniou, Z., Georgiou, M. (2023). Role of gender in stem education.

STEM education plays an important role in building knowledge and acquiring the skills needed for the 21st century. In fact, it is considered necessary for girls and boys to participate equally in it in order to achieve the 2030 Sustainable Development Goals. This paper examines the impact of students' gender on their interest and engagement in STEM education as reflected in the international literature in recent years. In addition, the corresponding effect of teachers' gender is also examined. The literature research revealed that there is a stereotypical belief among teachers regarding the gender of students who succeed in STEM subjects (i.e. boys), thus pushing female students to avoid these subjects, both at school and at a later professional level. On the contrary, the presence of female teachers enhances the confidence of female students and their engagement. However, the effect is multifactorial.

42. Stavrou, I., Boikos, I., Michalopoulos, V., Madrikas, A., Kyriakou, K., Stefanidou, C., & Skordoulis, C. (2023). Design, implementation and evaluation of a teachers' workshop on stem education.

The present study, which is part of a broader research project, concerns the design, implementation, and evaluation of a training seminar for teachers on STEM Education in the context of the “Diffusion of STEM” (DI-STEM) Project, funded by the Hellenic Foundation of Research and Innovation. The seminar was held in the three school-hubs of the Project by Athens Science and Education Laboratory project team with encouraging results. Key words: STEM education, teacher education.

**12<sup>th</sup> National conference. The role of science education in community of 21<sup>st</sup> century, ISBN 978-618-82007-4-6**





43. Kokolaki, A., Nipyrakis, A., Michailidi, E., Botzaki, E., Kendristaki, M., Drakoulaki, E., Bitsaki, C., Kapelonis, N., & Stavrou, D. (2021). Development of digital learning environments for pre – service teachers’ education in STEM advanced topics: The STEM - DIGITALIS project

The present program constitutes a collaboration of five academic institutions under the European Erasmus + program for the exchange of good practices in higher education. The main purpose of the program is the development of blended and distance learning environments for prospective primary and secondary science teachers’ education in contemporary scientific topics such as nanotechnology, climate change, renewable energy sources etc. Specifically, the criteria for selecting digital tools for digitization of STEM activities will be explored as well as the potential affordances and limitations of the digitized STEM activities that will be developed.

44. Nipyrakis, A., Kokolaki, A., Michailidi, E., Giannakoudaki, K., Metaxas, G., Kapelonis, N., Dimitriadi, K., & Stavrou, D. (2021). The Interdisciplinary STEM approach in Tertiary Education: The IDENTITIES project

The present program includes the cooperation of five academic institutes in the context of Erasmus+ projects for strategic partnerships for Higher Education. In particular, the program aims at developing STEM teaching modules for pre-service teacher education in both contemporary topics and traditional curriculum topics about the evolution of the disciplines, with a focus on theoretical principles of interdisciplinarity. Furthermore, several “lenses” of analysing interdisciplinarity are been implemented in order to stress the interconnections between the S-T-E-M disciplines. Up to the current state of the program, the modules developed and implemented relate to modeling the evolution of COVID-19, Nanotechnology, Parabolic Motion, Cryptography, Climate Change and Linguistics-Epistemology.

45. Nipyrakis, A., & Stavrou, D. (2021). Design & Development of STEM Teaching Material by In Service Secondary Teachers

The educational innovation of STEM teaching approach, albeit the potentialities and benefits that it offers, hasn’t still been successfully implemented in educational practice, whilst there is need to investigate the views of in-service teachers coming from the STEM disciplines on STEM. Particularly, the present study investigated (n=26) in-service teachers’ approach to designing and developing STEM teaching modules while working in groups, as well as the level of integration that they implement. Qualitative analysis of the developed teaching material and their discussions reveals diversity on STEM



integration approaches. Furthermore, teachers considered it important to collaborate with teachers with diverse expertise.

46. Apostolakakis, A., Dakanali, M., Kontopodis, M., Korakaki, E., & Perissinaki, I. (). Flash memory  
- STEM simulation device

This project presents a learning proposal that includes teaching scenarios and a device related to the STEM approach, focusing on topics of Nanoscience and Nanotechnology. This project was developed by a team of teachers of Secondary Education within the educational program of the University of Crete in the Field of Science Teaching “Modern Issues of Science and Technology”. The teaching scenarios combine subjects of Physics, Chemistry, Informatics, Technology and Mathematics, while the device highlights the connection between them. The device is a Flash memory model, whose functions represent the writing and reading of information like a real Flash memory.

47. Nipyrakis, A., & Stavrou, D. (2021). Design & Development of STEM Teaching Material in the context of Nanoscience-Nanotechnology

The present study includes a professional development program that was co-organised by academic researchers in cooperation with educational stakeholders. Participant in-service teachers were trained in interdisciplinary STEM teaching as well as in basic principles and applications of Nanoscience-Nanotechnology, and they subsequently designed and developed STEM teaching material (i.e. artefacts and lesson plans) in the field of NanoscienceNanotechnology.

48. Sidiropoulos, N., Altas, V., Vergerakis, P., Giakoumakis, A., Nikolakaki, N., Sismanidis, D. (2021). Educational Applications using the STEM Epistemology: The “Smart” Greenhouse

The present project introduces a STEM teaching module, as it was designed and developed from a group of in-service teachers in cooperation with an academic institute. The teachers developed a STEM artefact in the spirit of “smart” greenhouses, as well as STEM lesson plans. Furthermore, the developed module was implemented for teaching school students in terms of an environmental Erasmus+ project for Climate Change.

49. Markou, G., Panagiotaki, P., Vlachaki E. I.S., Menioudaki, E.-E., Stathopoulou, M., & Tsalmpouris, G. (2021). Autonomous Airplane for Environmental Monitoring.



A scenario of interconnection of courses in general and vocational high schools is proposed with the aim of building an automatic environmental monitoring plane. The scenario connects knowledge of engineering, aerodynamics, design, model construction, electrical engineering, electronics, biology, chemistry and mathematics. The teaching scenario was designed in the framework of an academic institute's program with the collaboration of teachers of various expertises. The plane was developed, and parts of the script were tested in the high schools that the teachers involved are assigned.

***11<sup>th</sup> National Greek conference of physics education and new technologies in education. Redefining Science and Technology Teaching and Learning in the 21st Century, Florina, 2019, ISBN: 978-618-83267-7-4***

50. Iatrou, P., & Spiliotopoulou, V. (2020). Primary Teachers' experiences with innovative projects and the formation of their concepts about the STEM perspective

This paper investigates primary teachers' perceptions in terms of the STEM practices in elementary classrooms and the meaning of integrating Science and Mathematics with everyday situations and the world of work. Structured interviews have been conducted with 6 teachers, who had been involved in innovative projects, with the goal to identify their positions and difficulties. This STEM integration seems to be conceptualized as cross-thematic approach, as connection of different subjects, as enrichment of teaching with everyday situations, and as contextualization of knowledge in teaching. In addition, conceptions of unified vision of knowledge, as well as science and mathematics as an integrated body of knowledge have appeared.

51. Michalopoulos, V., Kapotis, E., Kalkanis, G. (2020). Original STEM educational experimentations for hydrostatic pressure, buoyancy and float. Self-constructions - Research - Evaluation

This paper is an evaluated educational proposal for teaching hydrostatic pressure, buoyancy and float in middle school students. It consists of three inquiry-based worksheets, targeted to the deeper analysis of the aforementioned notions and the embellishment of their understanding, through experimentation with the original experimental devices and the application of new knowledge in the construction of a submarine, using common materials. The proposal was implemented on middle school students and the results, of the educational evaluation followed, show a statistically significant difference between the experimental and control groups, providing a finding that demonstrates the fulfillment of the proposal's principal goal.



52. Tsiastoudis, D., Maidou, A., & Polatoglou, H. (2020). Introduction to STEM education and experimentation using open hardware and software

In the present workshop we will showcase the basic functions of an Arduino board, the programming interface, the sensors, and the actuators. Through a series of hands-on activities, we will introduce the participants on how Arduino communicates with sensors, actuators and mobile devices or a desktop computer. In addition, we will explore possible applications of combinations of sensors and actuators in STEM education and science experimentation.

53. Patrinoopoulos, M., Iatrou, P. (2020). Implementation STEM Educational Practice of Elementary Education.

In this paper is presented the experiences of STEM practices in elementary education and it is sought to raise awareness of the potential for STEM activities to be introduced in Greek schools, given their context. The implementing schools were two co-located public elementary schools of Attika that implemented eight different actions. Indicatively, one of the activities carried in the 5th grade of Public Primary School is presented. Implementation revealed that educational scenarios are required to be carefully designed, with clear delineation and open to the solutions to be proposed. While their positive effect extends to multiple levels (cognitive, psychomotor, emotional).

***10<sup>th</sup> National Conference, Bridging the Gap between Science, Society and Educational Practice, Rethymnon, 2018, ISBN: 978-960-86978-3-6***

54. Komorek, M. (2018). Understanding out-of-school learning processes in stem disciplines - how to investigate and to develop student labs and exhibitions?

The graduate program "STEM-Learning in Extracurricular Learning Environments and their Integration into Regional Learning Contexts (GINT)" has started in October 2016. The program is funded by the Lower Saxony Ministry of Science and Culture. It is run by the University of Oldenburg in cooperation with the Universities of Hannover, Vechta, Odense (Denmark) and Rethymno (Greece). More than twenty extracurricular educational institutions, student labs, regional environmental education centers, Wadden Sea houses, energy training centers, coastal research institutes and museums are associated with the program. A total of twelve Georg Christoph Lichtenberg scholarships have been granted. Another four doctoral students with related topics joined the program. Doctoral students from geography education, computer science and technology education, natural sciences education,



philosophy education as well as from educational sciences are involved. They deal with the research of extracurricular subject-specific learning offers in the participating disciplines. They investigate how learning takes place in extracurricular learning environments in detail and how the offerings of an educational region could be networked and developed (Huber 2014) by integrating out-of-school learning opportunities into school curricula. Further information is available at: <https://www.uni-oldenburg.de/gint/>. The program implements a comprehensive qualification concept. Three-day workshops twice a year, regular seminars on core topics and research methods, small-scale work on data analysis and external lectures are provided. Additionally, a systematic presence of the doctoral students at conferences and an introduction to publication activities are supported.

55. Antonoglou, L., Kalampokis, I., Marouli-Hatziantoniou, K., Educating young students in science: an innovative STEM program for the young elementary school grades.

Science Technology Engineering and Mathematics (STEM) Education is an interdisciplinary and applied approach, based on learning through scientific research and its applications in the real world. An innovating STEM Program for early elementary school students (1st, 2nd and 3d Grade) has been developed and established since 2015 at Anatolia College in Thessaloniki. The STEM program, encourages students to love Science, gives students the opportunity to get involved in simple scientific practices and helps students to conceptualize, that through scientific research and practices everyday life questions and problems can be answered and solved.

56. Sifnioti, P., Froyntza, V., Kastani, E., Halari, F., Vlachou, A., Koutsaftouli, K., Liagkoura A., Karanana, E., Skandali Pouliou, P., Pertesi, A., Sotiropoulos, K., Apartoglou, Th., Spiliopoulou, E., Charalampopoulou, S., & Papakonstantinou, V. (2018). Life has its ups and down: An interdisciplinary STEM approach in the second grade.

An interdisciplinary approach and the connection to the real world are at the core of the STEM philosophy. In the above context, teachers at Costeas Geitonas School designed the programme “There is a reason for a season” for students in the second grade. Its aim is to understand the natural world by observing and recording the weather, through activities that touch upon, strengthen and link each of the STEM components.

57. Karnezou, M., & Mpalla, E. (2018). European hypatia program - formal stem education with gender equity.



Young Europeans have very little idea of the variety of careers related based on science, technology, engineering and mathematics (STEM). This has a particularly negative impact on the number of students following careers in STEM. HYPATIA brings schools, science museums, research institutions and industry together with gender experts and teenagers themselves and develops a unique toolkit of activities for engaging teenagers in STEM in a gender-inclusive way. These activities will be implemented in 14 countries and will empower teenage girls to choose STEM studies and careers. NOESIS is the Greek partner for HYPATIA project.

#### 4.2 Indicative journal publications or book chapters

58. Lazos, P., Stefanidou, C., & Skordoulis, C. (2024). Bridging the gap: From the laboratory science education of the 19th century in Greece to STEM education. *European Journal of Science and Mathematics Education*, 12(1), 1-10. <https://doi.org/10.30935/scimath/13826>

The objectives of the present study are to investigate both the history of the collection of scientific instruments from the Maraslean Teaching Center (MTC) and the potential for the collection's use in STEM education programs. Although MTC went by a number of different names during its long history, its institutional goal remained the same: training the Greek state's primary school teachers-to-be. To do so, it was necessary to assemble a collection of scientific instruments. The first objective of the paper is to present in detail the gradual enlargement of the collection from the last quarter of the 19th century through to the 1930s, along with the way the instruments were used in science lessons and the central role MTC played in relation to other regional teaching schools in Greece in terms of the distribution, administration, repair and maintenance of the equipment. The second objective is to investigate the role the historical scientific instruments can play not only in the history of science, but also in contemporary science teaching. The findings reveal that the history of laboratory physics education in MTC along with the corresponding collection of the historical scientific instruments can be a fertile ground for implementing STEM education programs. Finally, the findings imply the broader integration of STEM education and history of science in order to promote cultural and procedural aspects of science in student teachers and beyond. Such integration gives rise to broader research on introducing STEM education to cultural embedded environments, such as museums and historically important schools and laboratories, such as MTC.



59. Bounou, A., Lavidas, K., Komis, V., Papadakis, S., Manoli, P. (2023). Correlation between High School Students' Computational Thinking and Their Performance in STEM and Language Courses. *Education Sciences*, 13, 1101. <https://doi.org/10.3390/educsci13111101>

A longitudinal survey was executed to accomplish the correlation of computational thinking and courses related to STEM, commencing with administering a test designed to gauge the fundamental components of Computational Thinking. It is worth noting that this test draws its inspiration from internationally recognized computer competitions and serves as a credible assessment tool. Subsequently, an assessment was carried out to ascertain the degree of correlation between students' Computational Thinking aptitude and their written performance in the subjects encompassed by the STEM category and the Greek language courses. The outcomes of this investigation revealed the presence of a statistically significant correlation between students' Computational Thinking proficiency and their performance in these academic subjects, further extending to the academic direction of study chosen by the students. Based on the findings of this research, implications and pedagogical recommendations are delineated while concurrently acknowledging the limitations encountered during this study.

60. Kyprianou, G., Karousou, A., Makris, N., Sarafis, I., Amanatiadis, A., & Chatzichristofis, S.A. (2023). Engaging Learners in Educational Robotics: Uncovering Students' Expectations for an Ideal Robotic Platform. *Electronics*, 12, 2865. <https://doi.org/10.3390/electronics12132865>

The study aimed to understand students' expectations of an ideal robotic companion. We examined the desired characteristics, modes of interaction, and socialization that students anticipate from such a companion. By uncovering these attributes and standards, the authors aimed to inform the development of an optimal model that effectively fulfills students' educational aspirations while keeping them motivated and engaged.

61. Mereli, A., Niki, E., Psycharis, S., Drinia, H., Antonarakou, A., Mereli, M., & Maria, T. (2023). Education of students from Greek schools regarding natural disasters through STEAM. *Eurasia Journal of Mathematics, Science and Technology Education*, 19(8), em2314. <https://doi.org/10.29333/ejmste/13437>

The goal of the research is to educate students at primary schools in Greece on rapid ongoing natural disasters through the holistic-interdisciplinary science, technology, engineering, art, and mathematics (STEAM)-based method. As a learning tool, an integrated program was designed with a





variety of actions and activities aiming to experientially educate students in a holistic-interdisciplinary STEAM-based way. These are based on science, technology, engineering, art, and mathematics. This three-month program was chosen to be conducted in a private school of Attica, Greece, for the course “skill laboratories”. It was conducted to students of the second (seven years old) and the fifth grade of primary school (10 years old). In the beginning and the end of the program, the 133 participating students were given questionnaires, in order for the program to be assessed as to whether it managed to accomplish the initial goals. A total of 266 digital questionnaires were collected through ArcGIS survey123 application (part of geospatial cloud by Esri), which is an integrated solution for the creation, distribution and analysis of survey data. From the statistical analysis of their answers, the conclusion was that the vast majority of the students felt stress, confusion, depression and shock when they saw a forest fire. Most kids stated that they have thought of the consequences of extended wildfires and the flood events that follow.

62. Nikolopoulou, K. (2023). STEM activities for children aged 4–7 years: teachers’ practices and views, *International Journal of Early Years Education*, 31(3), 806-821.

The purpose of this study is to investigate teachers’ practices and views of STEM activities for children aged 4–7 years old. The participants are 18 Greek teachers and data is collected via interviews. Commonly reported reasons for the importance of STEM education are the development of skills, knowledge, and children’s interest for learning, while the skills children develop, include collaboration, communication, socialisation, problem-solving, experimentation, critical thinking, programming, creativity, and language/literacy. STEM activities implemented in class are programming, robotics and interdisciplinary activities, as well as experiments and exploration of materials. The primary factors considered when preparing STEM activities are children’s interest-motivation, their cognitive level or age, and the learning outcomes. Teachers’ perceived challenges mainly regard experiential learning, children’s interest and active participation, while main problems include limited time, infrastructure, and teacher training. Implications for educational policy-practice and teacher training are discussed.

63. Papagiannopoulou, T., Vaiopoulou, J., Stamovlasis, D. (2023). Teachers’ Readiness to Implement STEM Education: Psychometric Properties of TRi-STEM Scale and Measurement Invariance across Individual Characteristics of Greek In-Service Teachers. *Educ. Sci.*, 13, 299. <https://doi.org/10.3390/educsci13030299>



This study has focused on teachers' readiness for STEM education, where the prerequisite is to ensure valid measurements. In this study, we present the psychometric properties of the TRi-STEM scale, validated to measure teachers' readiness in implementing STEM education. The proposed scale was based on questionnaires that appeared in the literature, and the final form was adopted and refined for Greek in-service teachers (N = 494), via exploratory and confirmatory factor analyses. TRi-STEM comprises four dimensions: affective conditions (AC), cognitive conditions (CC), self-efficacy (SE), and STEM commitment (SC). The reliability measures of the four factors were AC ( $\alpha = 0.972/\omega = 0.972$ ), CC ( $\alpha = 0.976/\omega = 0.976$ ), SE ( $\alpha = 0.934/\omega = 0.935$ ), and SC ( $\alpha = 0.886/\omega = 0.885$ ), and confirmatory factor analysis showed a satisfactory fit [ $\chi^2(249) = 981.287$ ,  $p < 0.001$ , TLI = 0.942, CFI = 0.948, GFI = 0.993, NNFI = 0.942, RMSEA = 0.078 (0.073–0.083), and SRMR = 0.062]. In addition, measurement invariance was carried out for gender, age, years of service, school level, and university degrees. The TRi-STEM scale is an essential and applicable tool to ensure validity in educational research and support further hypotheses testing.

64. Samara, V., & Kotsis, K. T. (2023). Educational Robotics in Primary Education in Greece: Methodological Approaches and Attitudes of Teachers. A Bibliographic Review. *European Journal of Education and Pedagogy*, 4(2), 194–204. <https://doi.org/10.24018/ejedu.2023.4.2.629>

This study aims to highlight the methodological approaches of STEM in primary education, as well as practices that have been implemented in Greece. Initially, a brief theoretical framework of the teaching approach of STEM education is presented. Then the various methodological approaches that have been adopted at an international level are presented first, and then those applied in Greece for Primary Education. Finally, the attitudes of Primary Education teachers towards Robotics are listed.

65. Ampartzaki, M., Kalogiannakis, M., Papadakis, S., & Giannakou, V. (2022). Perceptions About STEM and the Arts: Teachers', Parents' Professionals' and Artists' Understandings About the Role of Arts in STEM Education. In: Papadakis, S., Kalogiannakis, M. (eds) *STEM, Robotics, Mobile Apps in Early Childhood and Primary Education. Lecture Notes in Educational Technology*. Springer, Singapore. [https://doi.org/10.1007/978-981-19-0568-1\\_25](https://doi.org/10.1007/978-981-19-0568-1_25)

This study presents the results of a survey conducted to explore the opinions of teachers, student-teachers, parents, artists, and STEM professionals. In summary, the results showed that: (a) although teachers, student-teachers, and STEAM professionals knew about the STEAM approach, only a few had the experience of implementing it; (b) the major difficulties educators faced in implementing STEAM



relate to understanding the methodological principles of this approach and the lack of educational resources; (c) educators had received limited support by policymakers, advisers, etc.; (d) STEAM was expected to enrich the curriculum with hands-on and active learning and have a positive impact on children's critical thinking and communication skills, as well as their overall development; (e) STEAM is expected to increase the motivation and participation of girls and disadvantaged students; and (f) educators and parents recognise the vulnerability of disadvantaged students, but do not seem to be aware of female underachievement in STEM subjects and careers.

66. Chatzopoulos, A., Kalogiannakis, M., Papadakis, S., & Papoutsidakis, M. (2022). A Novel, Modular Robot for Educational Robotics Developed Using Action Research Evaluated on Technology Acceptance Model. *Education Sciences*, 12, 274. <https://doi.org/10.3390/educsci12040274>

This research evaluates a novel, modular, open-source, and low-cost educational robotic platform in Educational Robotics and STEM Education. It is the sequel of an action research cycle on which the development of this robot is based. The impetus for the need to develop this came from the evaluation of qualitative and quantitative research data collected during an educational robotics event with significant participation of students in Athens, which showed an intense interest in students in participating in educational robotics activities, but—at the same time—recorded their low involvement due to the high cost of educational robots and robotic platforms. Based on the research's findings, this robot was designed to suit the whole educational community; its specifications came from its members' needs and the processing and analysis of qualitative and quantitative data. This paper presents an evaluation of the robot using the Technology Acceptance Model. The robot was exposed to 116 undergraduate students attending a pedagogical university department to evaluate its handling according to the model's factors. Research results were promising and showed a high degree of acceptance of the robot by these students and future teachers, providing the impetus for further research.

67. Chronis, C., & Varlamis, I. (2022). FOSSBot: An Open Source and Open Design Educational Robot. *Electronics*, 11, 2606. <https://doi.org/10.3390/electronics11162606>

In this work, the authors propose a new low-cost 3D-printable and unified software-based solution that can cover the needs of all age groups, from kindergarten children to university students. The solution is driven by open source and open hardware ideas, with which, we believe we will help educators in their work. They provide detail on the 3D-printable robot parts and its list of electronics that allow for



a wide range of educational activities to be supported, and explain its flexible software stack that supports four different operating modes. The modes cover the needs of users that do not know or want to program the robot, users that prefer block-based programming and less or more experienced programmers who want to take full control of the robot. The robot implements the principles of continuous integration and deployment and allows for easy updates to the latest software version through its web-based administration panel. Though, in its first steps of development and testing, the proposed robot has a huge potential, due to its open nature and the community of students, researchers and educators, that potential has kept growing. A pilot at selected schools, a performance evaluation of various technical aspects and a comparison with state-of-the-art platforms will soon follow.

68. Kalogiannakis, M., Papadakis, S. (2022). Preparing Greek Pre-service Kindergarten Teachers to Promote Creativity: Opportunities Using Scratch and Makey Makey. In: Murcia, K.J., Campbell, C., Joubert, M.M., Wilson, S. (eds) Children's Creative Inquiry in STEM. Sociocultural Explorations of Science Education, vol 25. Springer, Cham. [https://doi.org/10.1007/978-3-030-94724-8\\_20](https://doi.org/10.1007/978-3-030-94724-8_20)

This chapter describes the design, implementation, and evaluation of a semester-scale teaching intervention that involved 23 pre-service teachers who were provided 39 hours to do learning activities using Scratch 3 and MaKey MaKey. The intervention presents positive results concerning computational thinking concepts and coding skills based on a pedagogical practice that encourages active learning and emphasises intrinsic motivation and cognitive outcome. In conclusion, the students enjoyed the activities and, indeed, reported on having achieved a high level of confidence and sense of accomplishment. This study also highlights the importance of including robotics and visual blocks-based programming for pre-service teachers to improve CT knowledge and coding skills.

69. Kanaki, K., & Kalogiannakis, M. (2022). Assessing Algorithmic Thinking Skills in Relation to Age in Early Childhood STEM Education. *Education Sciences*, 12, 380.

This article reports a relevant research study, which we implemented under the umbrella of quantitative methodology, employing an innovative assessment tool we constructed for serving the needs of our study. The research was conducted within the context of the environmental study course, adding to the efforts of infusing CT into STEM fields. The study results shed light on the correlation between algorithmic thinking skills and age in early childhood, revealing that age is a predictor factor for algorithmic thinking and, therefore, for CT.



70. Kastriti, E., Kalogiannakis, M., Psycharis, S., & Vavougiou, D. (2022). The teaching of Natural Sciences in kindergarten based on the principles of STEM and STEAM approach. *Advances in Mobile Learning Educational Research*, 2(1), 268-277. <https://doi.org/10.25082/AMLER.2022.01.011>

This study is a literature and article review with its primary purpose to verify the importance of teaching Science in Preschool Education and its practicability at this age group. There is also a presentation of the holistic educational STEAM approach. The main goal of this presentation is to emphasize the contribution of this educational approach towards a more effective teaching of Science in Kindergarten and in-depth learning and understanding of natural concepts by preschoolers.

71. Mystakidis, S., Christopoulos, A. & Pellas, N. A (2022). Systematic mapping review of augmented reality applications to support STEM learning in higher education. *Educ Inf Technol* 27, 1883–1927. <https://doi.org/10.1007/s10639-021-10682-1>

This study reports findings from a systematic mapping review, based on a total of forty-five (n = 45) articles published in international peer-reviewed journals from 2010 to 2020, after evaluating the use of AR applications that support Science, Technology, Engineering and Mathematics (STEM) subjects' learning in HE settings. This review's results highlighted the lack of research across the STEM spectrum, especially in the Technology and Mathematics subfields, as well as the scarcity of location-based and markerless AR applications. Furthermore, three augmentation techniques, suitable for STEM learning, were identified and analysed: augmentation of laboratory specialised equipment, physical objects and course handbooks or sheets. The main contribution of this article is a taxonomy of instructional models and the discussion of applied instructional strategies and techniques in STEM fields focused on HE settings. In addition, we provide visualisations of the present state of the area, which aim at encouraging and scaffolding educators' efforts based on specific classification criteria to develop AR experiences and conduct further research to enhance STEM learning.

72. Nikolopoulou, K. (2022). Digital Technology in Early STEM Education: Exploring Its Supportive Role. In: Papadakis, S., Kalogiannakis, M. (eds) *STEM, Robotics, Mobile Apps in Early Childhood and Primary Education*. Lecture Notes in Educational Technology. Springer, Singapore.

This chapter aims to explore the supportive-complementary role of educational digital technology (or ICT) in early childhood STEM education. Digital technology tools include educational robotics, simulations, models, narrative-rich videos, and digital games. Indicatively, educational robotics provides



a learning environment where young children can apply computer programming skills, mathematical skills (numerical cognition, sequencing, patterns, counting, measuring, comparing, problem solving), and scientific skills and processes (scientific inquiry, conducting experiments, cause-effect relationships). The use of simulations enables hands-on experimental work and learning via investigations, while digital games aid children become familiar with the technology. Digital technology's support has the potential to enhance the benefits of STEM in early years, under conditions (teacher guidance, pedagogical strategies, etc.). It is suggested for teacher professional development to promote early STEM education with digital technology.

73. Tselegkaridis, S., & Sapounidis, T. (2022). Exploring the Features of Educational Robotics and STEM Research in Primary Education: A Systematic Literature Review. *Education Science*, 12, 305.

This article is a systematic literature review that tries to enrich the STEM agenda by answering the questions: (a) which study designs are commonly used in STEM interventions, (b) what the characteristics of the sample are (number/age of the students), (c) which equipment and user interfaces (tangible/graphical) are used, and (d) what are the characteristics of the studies (duration, intervention objectives, activities) and how studies' data were recorded. For this review, 36 out of 337 articles were analyzed and emerged from eight databases, three search-keywords and six exclusion criteria. The examination of the reviewed articles showed, inter alia, that non-experimental design is usually used, that in half of the cases written evaluations are used and the sample size is almost equal between girls and boys. Finally, long-term research is restricted, therefore it is not safe to generalize the findings of these studies.

74. Tselegkaridis, S., Sapounidis, T. (2022). A Systematic Literature Review on STEM Research in Early Childhood. In: Papadakis, S., Kalogiannakis, M. (eds) *STEM, Robotics, Mobile Apps in Early Childhood and Primary Education. Lecture Notes in Educational Technology*. Springer, Singapore. [https://doi.org/10.1007/978-981-19-0568-1\\_7](https://doi.org/10.1007/978-981-19-0568-1_7)

The present book chapter is a systematic literature review on STEM research in early childhood, focusing on STEM studies for students under 8 years old. For this purpose, the chapter includes articles, which were emerged from search keys in six scientific databases. The review presents some major characteristics of the studies such as: (a) the number of participants in the intervention (sample size), (b) the intervention objectives, (c) the size of groups, (d) the equipment type, (e) the materials used, and (f)





the type of research design. According to the findings, among others, STEM education in early childhood seems to successfully meet the teaching objectives, the group size is usually between 2 and 4 students, the long-term studies are absent and the quantitative methods are limited.

75. Tzafilkou, K., Perifanou, M., & Economides, A.A. (2022). STEM Distance Teaching: Investigating STEM Teachers' Attitudes, Barriers, and Training Needs. *Education Sciences*, 12, 790. <https://doi.org/10.3390/educsci12110790>

The aim of this study was to investigate STEM teachers' attitude towards STEM Distance Teaching (DT), as well as their perceived barriers and training needs. A mixed survey was conducted on 158 STEM teachers in secondary education who taught their courses fully online due to COVID-19. The results revealed that STEM teachers perceive STEM DT quite positively, but their attitude can be affected by several factors, such as the efficiency of the schools' digital infrastructure, as well as their gender, age, and STEM teaching subject. The qualitative thematic analysis identified several barriers to efficiently applying STEM DT, including the (i) lack of students' interaction and engagement, (ii) inefficiency of digital infrastructure, (iii) lack of students' and teachers' digital skills, (iv) lack of space/equipment, and (v) increased teaching workload. The generated themes of training needs highlighted the need for targeted and adjusted training to every STEM discipline, as well as training on DT tools and pedagogies. Finally, the results indicated the STEM teachers' need for psychological support and consulting.

76. Gözü, A. I.C., Papadakis, S., & Kalogiannakis, M. (2022). Preschool teachers' STEM pedagogical content knowledge: A comparative study of teachers in Greece and Turkey. *Front. Psychol.* 13:996338 <https://doi.org/10.3389/fpsyg.2022.996338>

This study compares the STEM Pedagogical Content Knowledge of Greek and Turkish preschool teachers. The present research is a comparative descriptive study that aims to determine the STEM Pedagogical Content Knowledge of preschool teachers from Greece and Turkey. A descriptive survey model, a method used in quantitative research, was used as this study's primary research method. The STEM Pedagogical Content Knowledge Scale (STEMPCK) was used in this study. Six hundred sixty-nine preschool teachers - 104 Greek and 565 Turkish teachers - participated in this study. The STEMCK Scale's construct validity and reliability were tested using this study's data set, which was found to be both valid and reliable. No significant difference was found between the STEMCK scores of Greek and Turkish preschool teachers. The significant differentiation of STEMCK scores based on whether the teachers had





received any STEM training is discussed in light of the relevant literature. This study determines and compares STEMPCK among preschool teachers from disparate countries such as Greece and Turkey and is expected to contribute to the literature.

77. Chondrogiannis, E.; Symeonaki, E.; Papachristos, D.; Loukatos, D.; Arvanitis, K.G. Computational Thinking and STEM in Agriculture Vocational Training: A Case Study in a Greek Vocational Education Institution. *Eur. J. Investig. Health Psychol. Educ.* 2021, 11, 230-250. <https://doi.org/10.3390/ejihpe11010018>

The present case study aims to explore the relation between CT, STEM and agricultural education training (AET) in a Greek vocational training institute (IEK), the Agriculture IEK of Metamorfosis city (IEKMC), which is active in agriculture education. The research methodology is utilized according the positivist philosophical approach through data acquisition employing a questionnaire and the quantitative (statistical) analysis of data collected. The sample consists of IEKMC educators and students selected based on simple random sampling. Based on the participants belief that CT and STEM philosophy add value in the learning process, it focuses on the application of knowledge in the real world (students) and problem solving using new technologies (educators). Educators consider “experiments” as the most significant educational tool for problem solving in teaching practice. Students rate Greek Agriculture Education and Training (GAET) higher than educators. However, the participants evaluate GAET very low due to the lack of new innovative teaching methods being introduced. Finally, there is great interest in the implementation of CT and STEM in the European Union (EU) by students and educators.

78. Papadakis, S., Vaiopoulou, J., Sifaki, E., Stamovlasis, D., & Kalogiannakis, M. (2021). Attitudes towards the Use of Educational Robotics: Exploring Pre-Service and In-Service Early Childhood Teacher Profiles. *Education Sciences*, 11, 204. <https://doi.org/10.3390/educsci11050204>

The present study concerns in-service and pre-service early childhood teachers, focusing on their perceptions and attitudes about ER use in daily teaching practice. The data were collected via a questionnaire (N = 201) and explored using latent class analysis, which detected distinct clusters/profiles of participants based on their pattern of responses. Two clusters were identified: Cluster1 was relatively homogeneous, including those who share a positive attitude towards ER, while Cluster2 was heterogeneous, comprising participants with inconsistent responses and expressing negative and skeptical thinking. The cluster memberships were associated with external covariates, such as age, years



of teaching experience, and variables measuring their technological competencies. The results showed that teaching experience and age were negatively associated with cluster1-membership, while educational robotics knowledge was positively associated. The findings are interpretable, and the implications for education are discussed considering the current literature.

78. Tzagkaraki, E., Papadakis, S., Kalogiannakis, M. (2021). Exploring the Use of Educational Robotics in Primary School and Its Possible Place in the Curricula. In: Malvezzi, M., Alimisis, D., Moro, M. (eds) Education in & with Robotics to Foster 21st-Century Skills. EDUROBOTICS 2021. Studies in Computational Intelligence, vol 982. Springer, Cham. [https://doi.org/10.1007/978-3-030-77022-8\\_19](https://doi.org/10.1007/978-3-030-77022-8_19)

This paper is a brief review of the literature on the use of educational robotics in primary school. The purpose is to explore the application of robotics and, more specifically, the advantages robotics offers to students, the challenges that arise from its application, and what is its place in the curricula. Educational robotics is an innovative and useful tool. It positively affects critical thinking, computational thinking, problem-solving, algorithmic thinking, creativity, and collaboration. The literature reveals that difficulties arise either at the technical level or due to teachers' lack of relevant knowledge or the lack of relevant provisions for their effective integration into primary school curricula.

79. Christopoulos, A., Pellas, N., Laakso, M.-J. (2020). A Learning Analytics Theoretical Framework for STEM Education Virtual Reality Applications. Education Sciences, 10, 317.

While virtual reality has attracted educators' interest by providing new opportunities to the learning process and assessment in different science, technology, engineering and mathematics (STEM) subjects, the results from previous studies indicate that there is still much work to be done when large data collection and analysis is considered. At the same time, learning analytics emerged with the promise to revolutionise the traditional practices by introducing new ways to systematically assess and improve the effectiveness of instruction. However, the collection of 'big' educational data is mostly associated with web-based platforms (i.e., learning management systems) as they offer direct access to students' data with minimal effort. Thence, in the context of this work, we present a four-dimensional theoretical framework for virtual reality-supported instruction and propose a set of structural elements that can be utilised in conjunction with a learning analytics prototype system. The outcomes of this work are expected to support practitioners on how to maximise the potential of their interventions and provide further inspiration for the development of new ones.



80. Kalogiannakis, M., & Papadakis, S. (2020). The Use of Developmentally Mobile Applications for Preparing Pre-Service Teachers to Promote STEM Activities in Preschool Classrooms. In book: Mobile Learning Applications in Early Childhood Education Publisher: IGI Global, DOI: 10.4018/978-1-7998-1486-3.ch005

Studies suggest that the exposure to STEM learning opportunities early in life is important because the development of STEM skills can further students' interest and educational attainment in STEM, expanding their career choices later in life. Smart mobile devices have become ubiquitous in schools and have been transforming educational practices at all ages and levels and almost all over the world. At the same time, there is evidence that teacher education departments lack the knowledge and skill to teach pre-service teachers about using these devices in their daily teaching practice. The findings of this chapter underline the need to develop teaching and learning processes that go beyond a mere transmission of the technical knowledge required to use mobile technologies with educational purposes, focusing instead on raising students' awareness about the educational benefits that the integration of mobile technologies can bring to formal education.

81. Pellas, N., Dengel A., & Christopoulos, A. (2020). Scoping Review of Immersive Virtual Reality in STEM Education. In IEEE Transactions on Learning Technologies, 13(4), 748-761, <https://doi.org/10.1109/TLT.2020.3019405>.

This article presents various VR-supported instructional design practices in K-12 (primary and secondary) and higher education in terms of participants' characteristics, methodological features, and pedagogical uses in alignment with applications, technological equipment, and instructional design strategies. During the selection and screening process, 41 (n = 41) studies published in the period 2009-2019 were included for a detailed analysis and synthesis. This article's results indicate that many studies were focused on the description and evaluation of the appropriateness or the effectiveness of applied teaching practices with VR support. Several studies pointed out improvements in learning outcomes or achievements, positive perspectives on user experience, and perceived usability. Nevertheless, fewer studies were conducted to measure students' learning performance. The current scoping review aims to encourage instructional designers to develop innovative VR applications or integrate existing approaches in their teaching procedures. It will also inform researchers to conduct further research for an in-depth understanding of the educational benefits of immersive-VR applications in STEM fields.



82. Psycharis, S., & Kotzampasaki, E. (2019). The Impact of a STEM Inquiry Game Learning Scenario on Computational Thinking and Computer Self-confidence. *Eurasia Journal of Mathematics, Science and Technology Education*, 15(4). doi:10.29333/ejmste/103071

The current empirical research aims to study the impact of a STEM content Inquiry based scenario using computational tools and educational games, regarding computational thinking (CT) and confidence for “computers use” of 115 students of Greek public schools of the 5th-6th grade. For the needs of this research, a didactic scenario was developed and implemented, using computational tools, such as the Arduino microcontroller, RGB Led’s while a computational model was designed and implemented. The assessment of computational thinking improvement and confidence for computers use was conducted with the use of questionnaires that were administered before and after the intervention. The findings indicate a positive influence of the intervention on the dimensions of computational thinking in the experimental group. The findings can be applied to educational settings that integrate STEM in the teaching sequence in order to enhance students’ confidence with computational experiments.

83. Nikou, S. A., & Economides, A. A. (2018). Factors that influence behavioral intention to use mobile-based assessment: A STEM teachers’ perspective. *British Journal of Educational Technology*. doi:10.1111/bjet.12609

This study explores science technology engineering and mathematics (STEM) teachers’ intention to use mobile based assessments in the teaching practice. The study proposes the teachers’ acceptance mobile-based assessment (TAMBA) model which extends the technology acceptance model by introducing individual, social, institutional and instructional design factors. An appropriate questionnaire was developed and answered by 161 STEM teachers from 32 European countries. Their responses were analyzed using structural equation modeling. The proposed TAMBA model explains about 50% of the variance in teachers’ intention to adopt mobile-based assessment. Perceived Ease of Use was found to be the most important determinant in teachers’ intention to use mobile-based assessment. Facilitating Conditions and Output Quality were the most influential external variables in the model. The study findings revealed that focusing on mobile assessment quality design as well as on institutional support are important factors for STEM teachers in order to accept mobile-based assessments in schools.



84. Kordaki, M., & Berdousis, I. (2015). Computing and STEM in Greece: Gender representation of students and teachers during the decade 2002/2012. *Education and Information Technologies*, 22(1), 101–124. doi:10.1007/s10639-015-9432-2

This study focuses on the investigation of gender representation of tertiary-level education students (freshmen, graduates, master's degree graduates and PhD's) and of secondary-level education teachers in Computing and STEM education during the decade 2002–2012 in Greece. A quantitative study was conducted taking into account appropriate data that emerged from the Hellenic Statistical Authority which is the national statistical service of Greece. During the studied decade:(a) Females were less prevalent than males at all levels of study in Computing and Engineering, (b) the number of males did not exceed that of females in Physics (freshmen, graduates and master's degree holders) or in Mathematics (graduates),(c) Female teachers were less prevalent than males in Computing and STEM,(d) Computing female schoolteachers are better represented at all levels of secondary education compared to the representation of their female counterparts in the rest of the disciplines of STEM education,(e) There is no pipeline shrinkage between female freshmen and graduates of undergraduate studies in Computing and STEM and there was also no female dropout from level (undergraduate studies) to level (master's degree studies) in Greek Computing, Physics and Engineering departments. It seems that the main problem is recruitment and not retention in Computing and STEM, despite female under-representation in most of these disciplines.

#### 4.3 Summary

Eighty-four research studies related to STEM education coming from Greek researchers have gathered. Fifty-seven were presented at conferences from the two major scientific associations.

Thirty-three studies came from the “Hellenic Scientific Association of Information & Communication Technologies in Education” and 24 from the “Association for Science Education and Technology” during 2015-2023. Moreover, 27 research journal articles and volume chapters were gathered.

As expected, the 33 articles from the “Hellenic Scientific Association of Information & Communication Technologies in Education” have Information and Communication Technologies as their



main component. They refer mainly to computational thinking, robotics and hardware interfaces, which are topics from certain STEM fields.

Similarly, the 27 articles from the “Association for Science Education and Technology” have Sciences as their main components. They mainly concern science projects, students and teachers attitudes towards STEM, seminars for students and teachers as well as the design and implementation of STEM educational scenarios.

Journal articles and volume chapters follow the same direction.

It is noteworthy that integrated STEM approaches are the minority of the research studies.



## 5 Empirical studies

To determine the attitudes of in-service teachers, graduates of pedagogical departments and experts towards STEM education, three exploratory surveys were conducted. This section presents the results from this study.

### 5.1 Teachers' attitudes

This survey was addressed to:

1. teachers who have taught or are teaching topics from the STEM fields
2. teachers who apply the integrated STEM approach.

The research sample was secondary school teachers, specifically: Mathematicians, Science teachers, Engineers and Computer Science teachers. A total of 26 filled questionnaires returned through the Google Forms.

The results are presented per question.

**Q1: Have you taught or are you teaching STEM-related subjects (e.g., as part of Skills Labs or programs)?**

14 of the teachers stated that they have taught or are teaching STEM-relevant subjects, while 12 stated the opposite (Fig. 6.1.1)

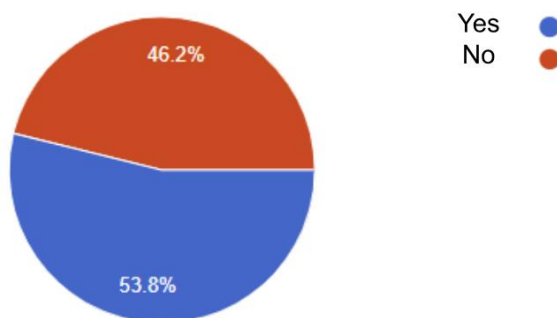


Fig 6.1.1: Distribution of Opinions: teaching STEM-related subjects

**Q2: Have you followed or are you following the integrated STEM approach?**





14 of the teachers stated that they do not follow the integrated STEM approach, while 12 stated they do (Fig. 6.1.2).

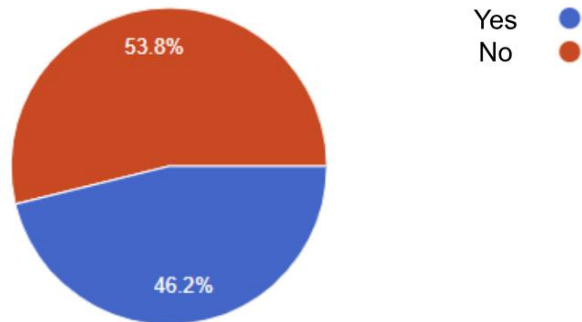


Fig 6.1.2: Distribution of Opinions: following the integrated STEM approach

**Q3: How often do you use audio-visual materials when teaching STEM-related topics?**

Eight teachers answered “Often”, seven “Sometimes”, three use it in every lesson, six answered “Rarely”, while two teachers declared that they do not include audio/video materials in STEM lessons (Fig. 6.1.3).

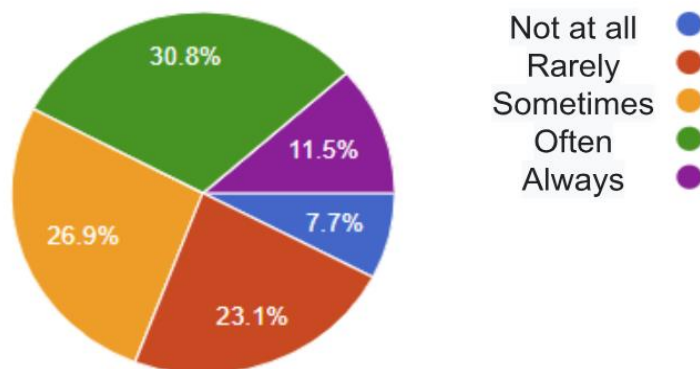


Fig 6.1.3: Use of audio-visual materials

**Q4: How often do you use STEM-specific software when teaching STEM-related topics?**



Seven teachers answered “Often”, seven “Rarely”, two use it in every lesson, five answered “Sometimes”, while five teachers declared that they do not use STEM-specific software (Fig. 6.1.4).

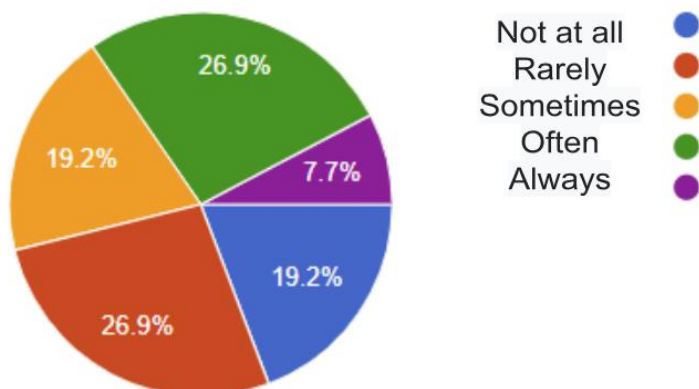


Fig 6.1.4: Use of STEM-specific software

#### Q5: Where do you look for educational materials for teaching STEM subjects?

Sixteen of the participants look for relevant sources on the world wide web, 5 look for sources in educational repositories (e.g., Scientix), two follow private channels that publish STEM resources (social networks, informative newsletters, etc.), two prefer the material offered by the Greek state and one follows national and international channels of STEM educational projects with public funding (Fig. 6.1.5)

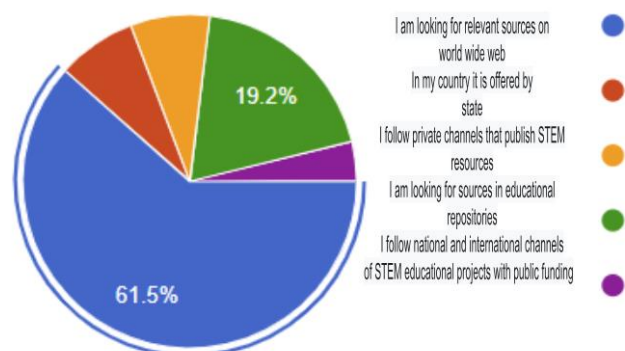




Fig 6.1.5: Sources of educational materials

**Q6: Is your STEM teaching affected by possibly inadequate technical assistance?**

Seven teachers answered “Often”, seven answered “Sometimes”, seven “Rarely”, two are not affected and three are affected all the time (Fig. 6.1.6)

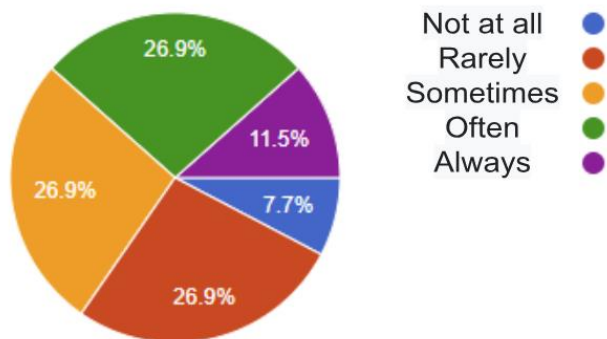


Fig 6.1.6: Inadequate technical assistance affecting STEM teaching

**Q7: Is the teaching of STEM subjects affected by the lack of material in Greek?**

Nine teachers are sometimes affected, eight are often affected, four are always affected, four rarely affected and one is not at all affected (Fig. 6.1.7)

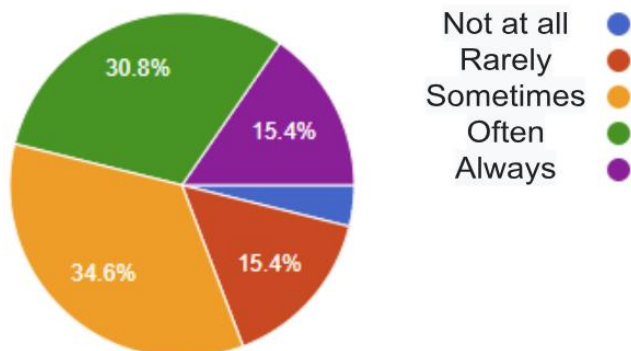


Fig 6.1.7: Lack of material in Greek affecting STEM teaching



**Q8: To what extent do you have support from experts outside of school to enhance your knowledge of STEM subjects?**

Twenty teachers have little or no support, three have both technical and pedagogical support, two have mainly technical support and one has mainly pedagogical support (Fig. 6.1.8)

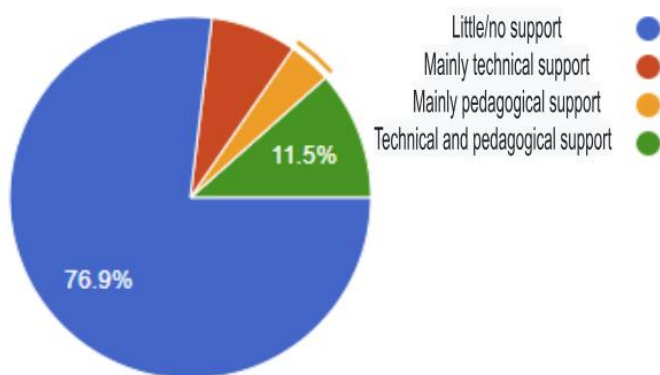


Fig 6.1.8: Support provided

**Q9: Do you think that innovative STEM education (use of digital technology and innovative pedagogical approaches) has a positive effect in making students work harder at what they are learning?**

Eleven teachers answered “Fairly”, eight answered “A lot”, six “Minimum” and one “Not at all” (Fig. 6.1.9)

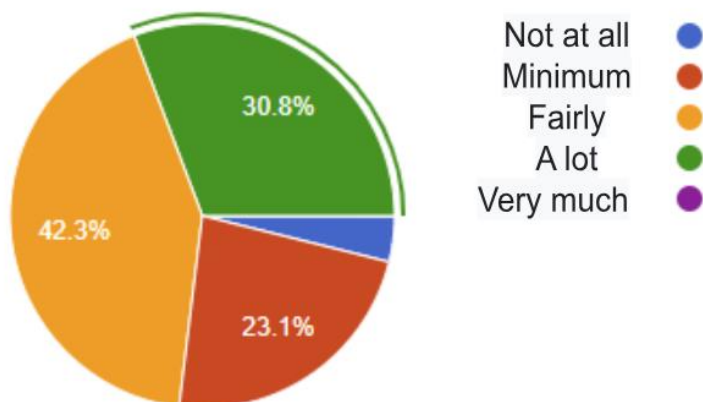


Fig 6.1.9: Opinions on positive effects on making students work harder

**Q10: Do you think that innovative STEM education (use of digital technology and innovative pedagogical approaches) results in a better understanding of subjects by students?**

Twelve teachers believe that STEM education results a lot on a better understanding of subjects by students, ten declared an average impact, two answered “very much”, and two either declared minimum or no impact (Fig. 6.1.10)

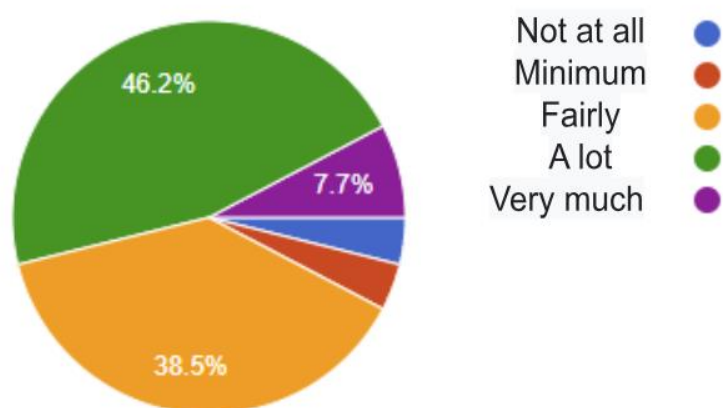


Fig 6.1.10: Opinions on positive effects on students' better understanding



## 5.2 Postgraduate students' opinions

This survey was addressed to 12 postgraduate students of the Master's Program "Didactics And Learning Techniques In Natural Sciences" conducted at of the Department of Primary Education of the University of Ioannina. Throughout the survey a 5-point Likert scale was used, rating from "Not at all/Totally disagree" (1) to "Very much/Totally agree" (5).

The results are presented per question.

**Q1: In your opinion, innovative STEM teaching (using ICT and innovative pedagogical methods) has a positive impact on the following:** (Very much – Not at all)

### 1.1 Students concentrate more on what they are learning

One student answered "Very much", nine answered "A lot" and two "Enough" (Fig 6.2.1).

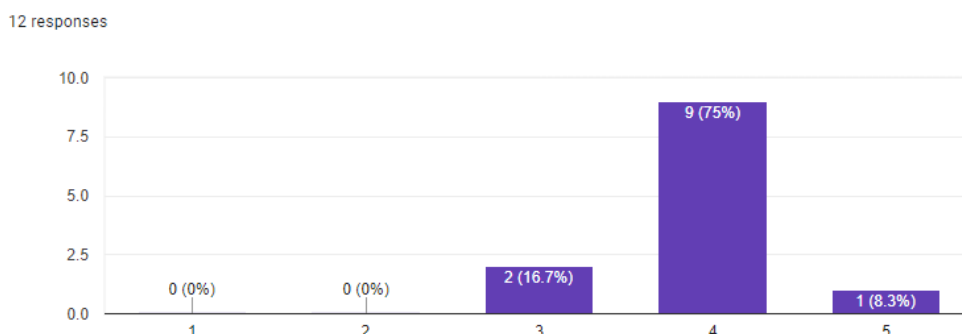


Fig 6.2.1 Opinions about STEMS' impact on concentration

### 1.2 Students put more effort into the subject they are studying

Nine students answered "A lot", two answered "Enough" and one answered "A little" (Fig 6.2.2).



12 responses

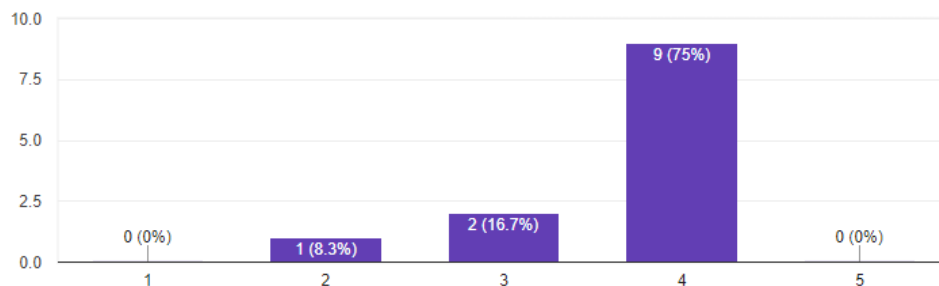


Fig 6.2.2 Opinions about STEMs' impact on effort

1.3 Students feel that they enjoy more autonomy when learning (they can repeat exercises if needed, explore topics that interest them in more detail, etc.)

Six of the participants answered “Very much”, five “A lot” and one answered “Enough” (Fig 6.2.3).

12 responses

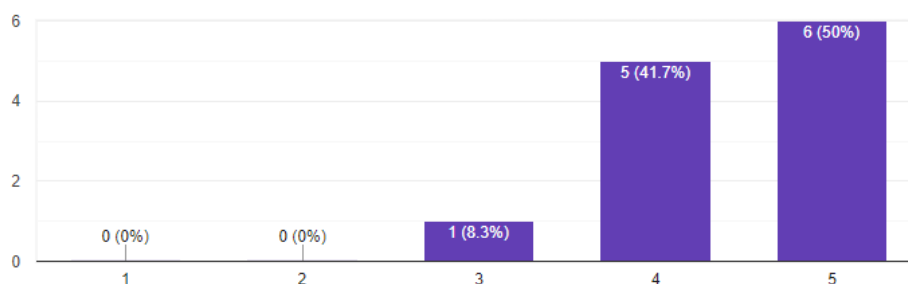


Fig 6.2.3 Opinions about STEMs' impact on autonomy

1.4 Students understand what they learn more easily

Two students answered “Very much”, nine “A lot” and one answered “Enough” (Fig 6.2.4).





12 responses

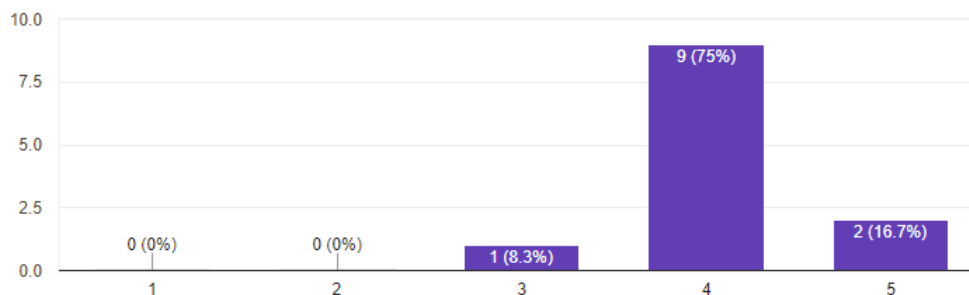


Fig 6.2.4 Opinions about STEMs' impact on understanding

### 1.5 Students remember what they learned more easily

Two of the participants answered “Enough”, nine “A lot” and one answered “Very much” (Fig 6.2.5).

12 responses

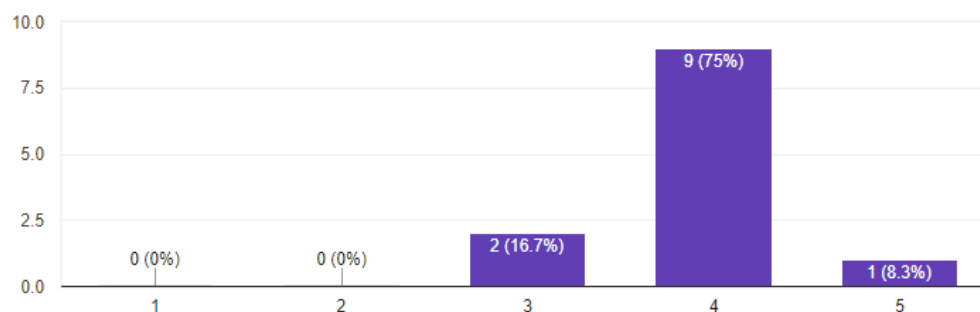


Fig 6.2.5 Opinions about STEMs' impact on memory

### 1.6 Students develop critical thinking

Two participants answered “Very much”, nine “A lot” and one answered “Enough” (Fig 6.2.6).



12 responses

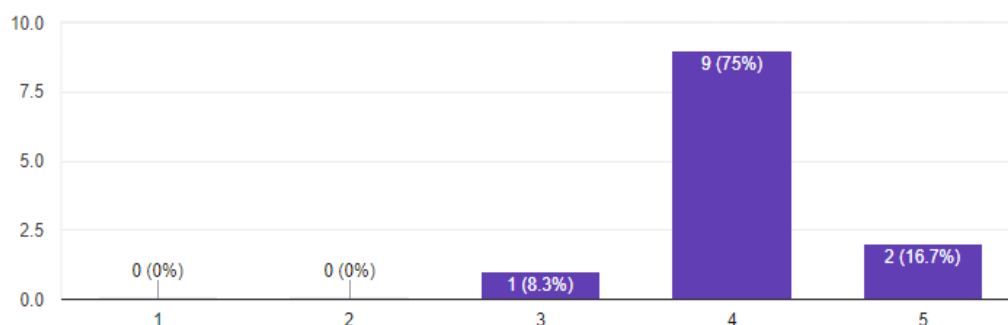


Fig 6.2.6 Opinions about STEMs' impact on critical thinking

### 1.7 Students' interest in STEM careers is stimulated

Four students answered “Very much”, seven “A lot” and one answered “Enough” (Fig 6.2.7).

12 responses

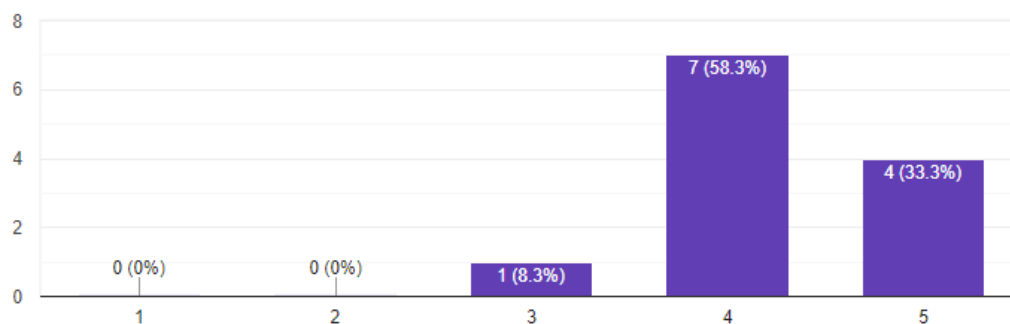


Fig 6.2.7 Opinions about STEMs' impact on interest in STEM careers

### 1.8 ICT facilitates collaborative work between students

Two participants answered “Very much”, six “A lot” and four answered “Enough” (Fig 6.2.8).



12 responses

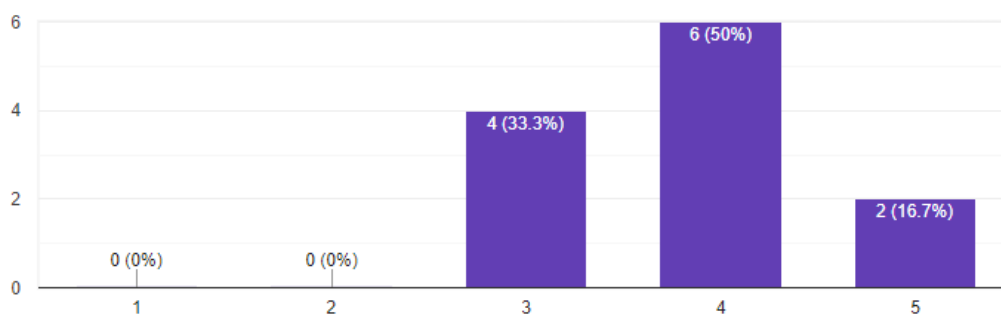


Fig 6.2.8 Opinions about STEMs' impact on collaborative work

### 1.9 ICT improves classroom climate (students concentrate better, make less noise)

Seven students answered "A lot" and five answered "Enough" (Fig 6.2.9).

12 responses

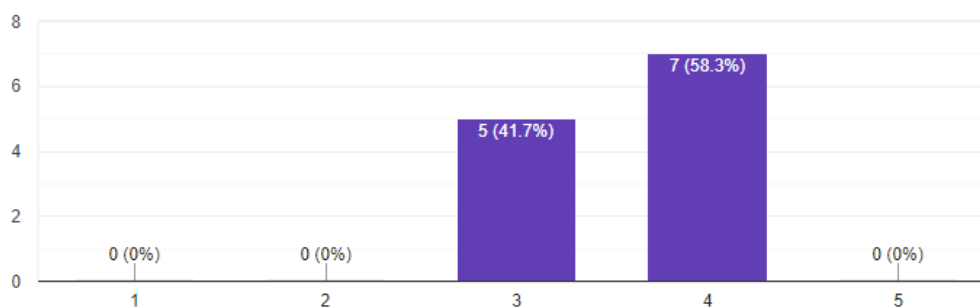


Fig 6.2.9 Opinions about STEMs' impact on classroom climate

**Q2: ICT should be used so that students:** (Totally disagree – Totally agree)

### 2.1 do exercises and practice

Five of the participants totally agree and seven agree (Fig 6.2.10).



12 responses

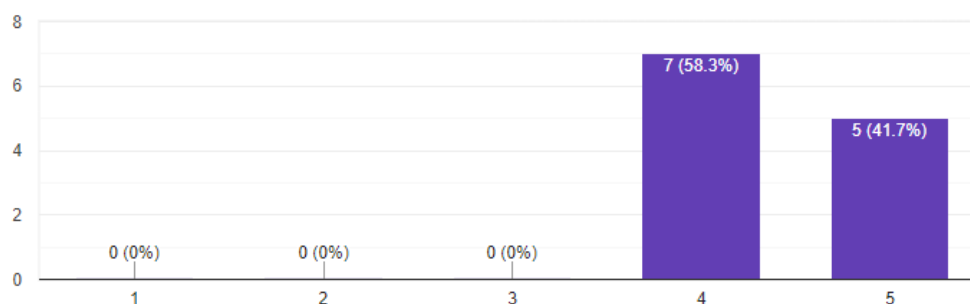


Fig 6.2.10 Opinions about ICT's use to do exercises and practice

## 2.2 retrieve information

Seven of the participants totally agree, four agree and one is neutral (Fig 6.2.11).

12 responses

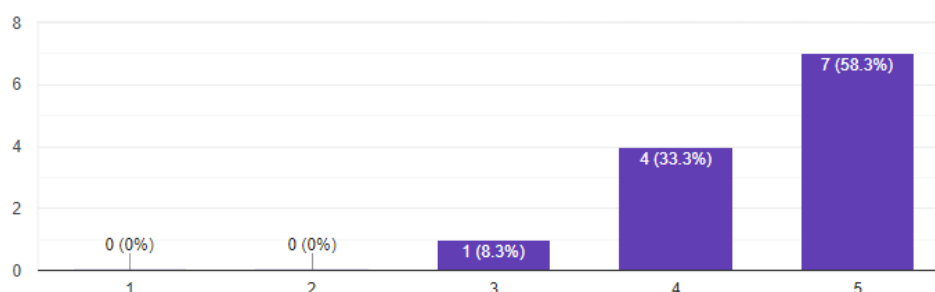


Fig 6.2.11

Opinions about ICT's use to retrieve information

## 2.3 work cooperatively

Six of the participants totally agree, four agree and two are neutral (Fig 6.2.12).



12 responses

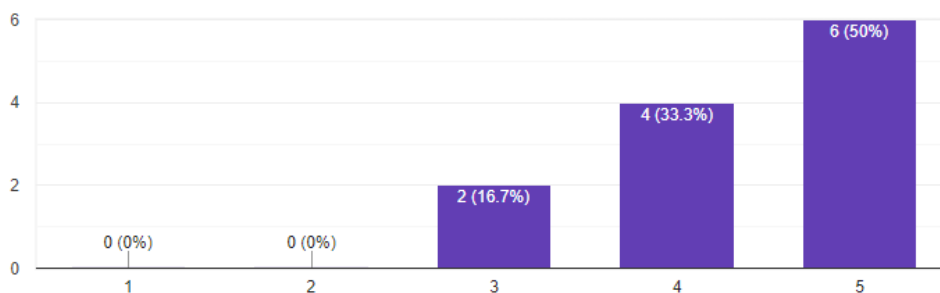


Fig 6.2.12 Opinions about ICT's use to work cooperatively

#### 2.4 learn in an autonomous way

Five students totally agree and seven agree (Fig 6.2.13).

12 responses

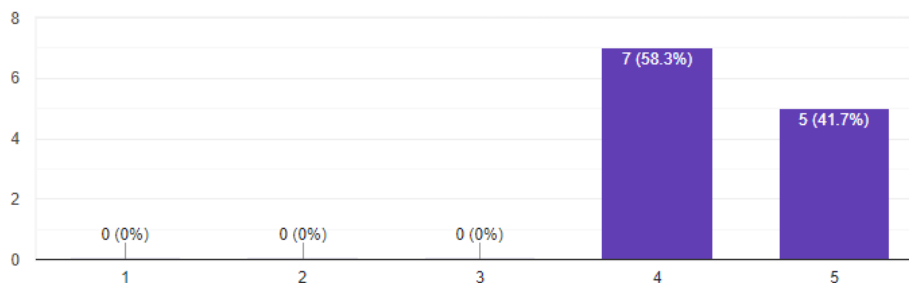


Fig 6.2.13 Opinions about ICT's use to learn in an autonomous way

**Q3: The use of ICT in teaching and learning positively affects:** Totally disagree – Totally agree

#### 3.1 The students' internal motivation

Eleven students agree and one is neutral (Fig 6.2.14).



12 responses

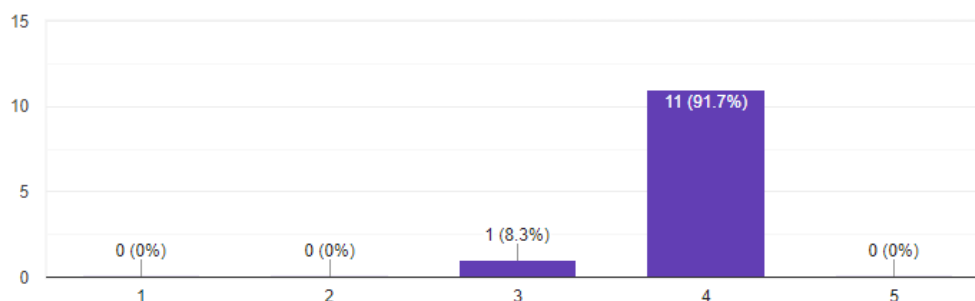


Fig 6.2.14 Opinions about ICT effect on students' internal motivation

### 3.2 Student achievements

Two of the participants totally agree, seven agree and three are neutral (Fig 6.2.15).

12 responses

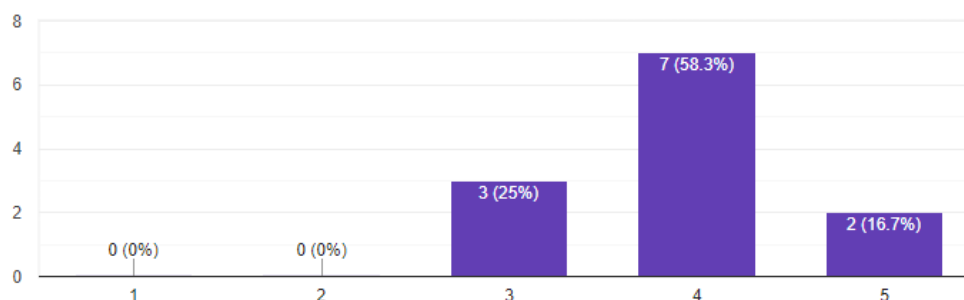


Fig 6.2.15 Opinions about ICT effect on students' achievements

### 3.3 Higher-level skills (deep understanding)

Two of the participants totally agree, seven agree and three are neutral (Fig 6.2.16).



12 responses

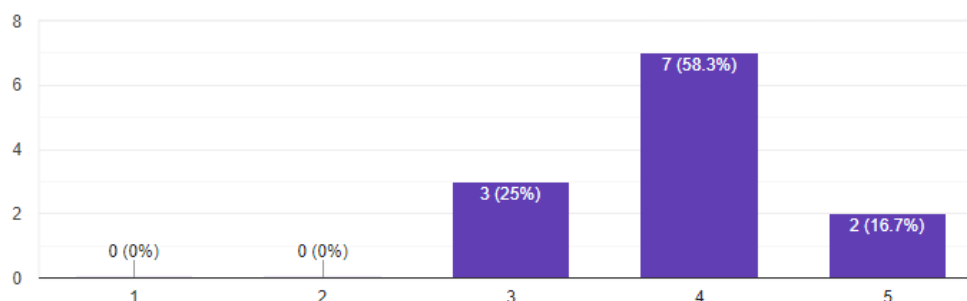


Fig 6.2.16 Opinions about ICT effect on Higher-level skills

### 3.4 The ability in transversal skills (metacognitive skills, social skills, etc.)

One student totally agrees, nine agree and two are neutral (Fig 6.2.17).

12 responses

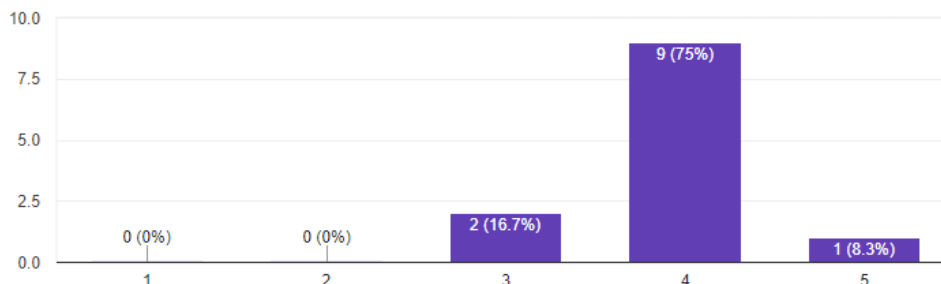


Fig 6.2.17 Opinions about ICT effect on transversal skills

**Q4: The use of ICT in teaching and learning is essential for students to be properly prepared for life and work in the 21<sup>st</sup> century** (Totally disagree – Totally agree)

Five students totally agree and seven agree (Fig 6.2.18)





12 responses

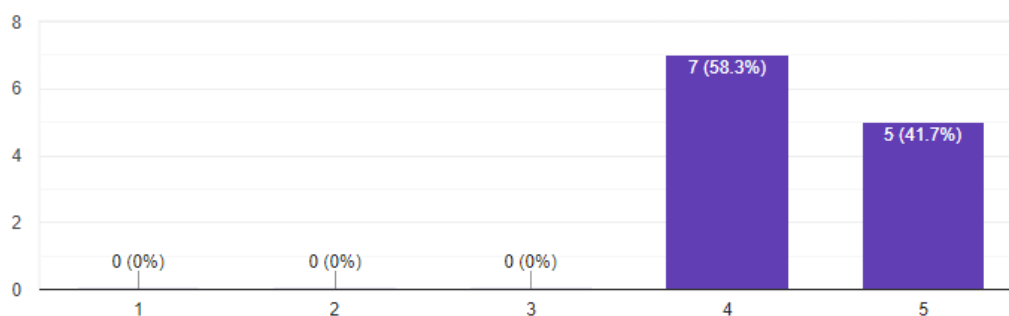


Fig 6.2.18 4 Opinions about ICT's usage in teaching and learning impact on students' preparation for life and work



### 5.3 Researchers' opinions

This survey was addressed to nine researchers of the Department of Primary Education, University of Ioannina. All hold PhDs on Learning Technologies or Science Education and have worked/work on STEM related projects or have taught/teach STEM subjects.

The results are presented per question.

**Q1: How would you rate the situation regarding STEM education in your country?** (5-point Likert scale rating from “Very Poor” to “Very Good”)

One participant rated the situation as “Very poor”, five as “Poor”, two as “Acceptable” and one participant rated the situation as “Good” (Fig. 6.3.1).

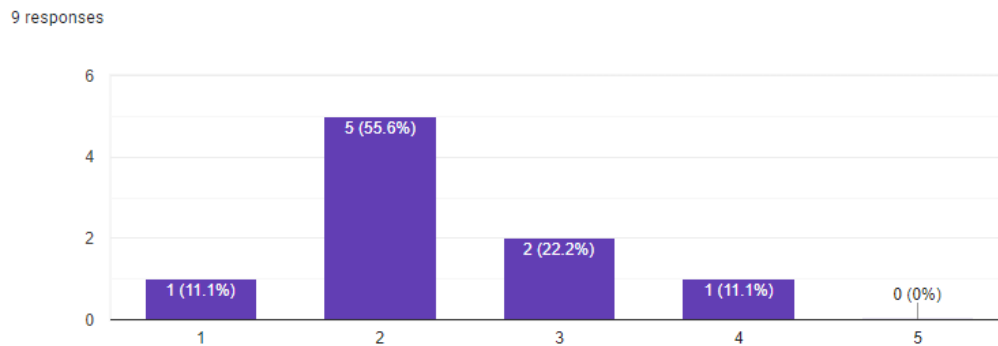


Fig. 6.3.1 Situation regarding STEM education in your country

**Q2: In what ways can you contribute to the improvement of STEM education policies and practices?**

Four stated “enhancing teachers' competencies”, three “development of STEM education policies and practices overall” and two “development of new teaching materials” (Fig. 6.3.2).

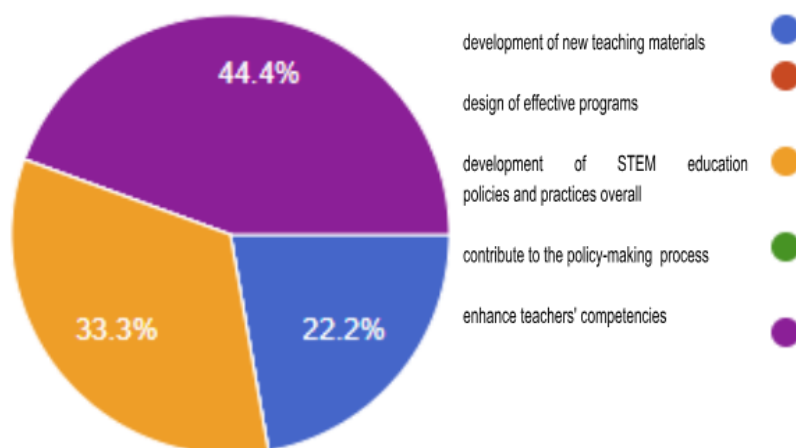


Fig. 6.3.2 Ways of contribution to the improvement of STEM education

### Q3: Do you take part in STEM education research?

Out of the nine participants only three are currently involved in STEM education research (Fig. 6.3.3).

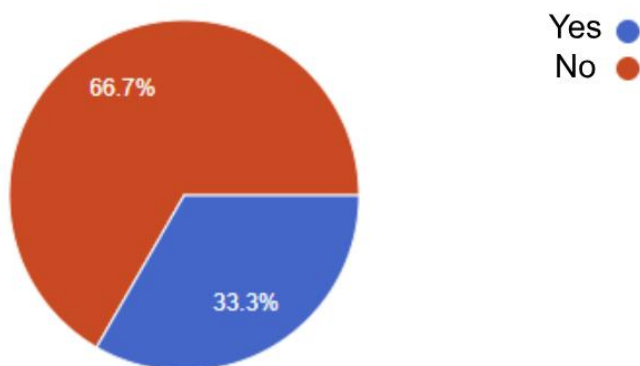


Fig. 6.3.3 Participation in STEM education research

IF YES: Your research focuses on:

Out of the three positive responses 2 focus on “teacher candidates” and 1 on “elementary school students” (Fig. 6.3.4).

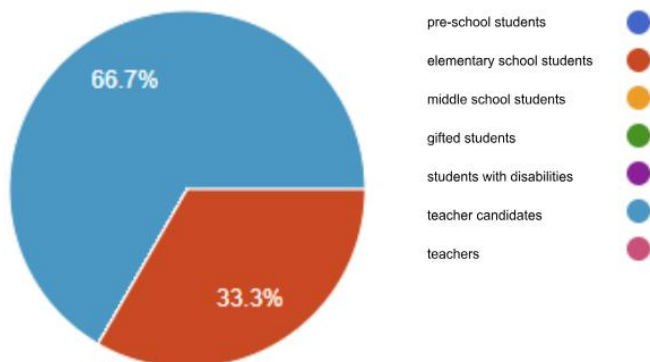


Fig. 6.3.4 Participants in STEM education research

IF YES: Your main source of research documents is:

Out of the three positive responses two declared “Published articles” and one person “Curricula” to be their main source of research documents (Fig. 6.3.5).

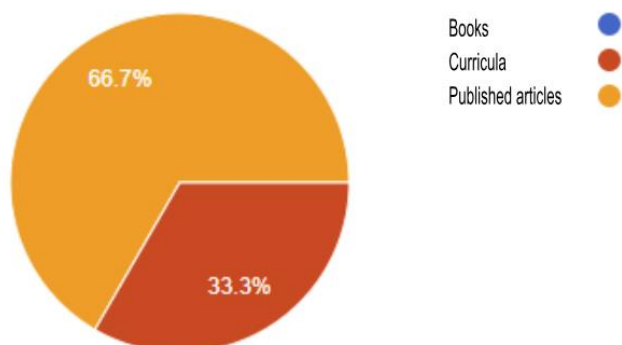


Fig. 6.3.5 Sources for STEM education research

IF YES: Your research on STEM education focuses most on:

“STEM teacher training”, “digital skills” and “robotics” were the subjects that the three researchers focus on. (Fig. 6.3.6).

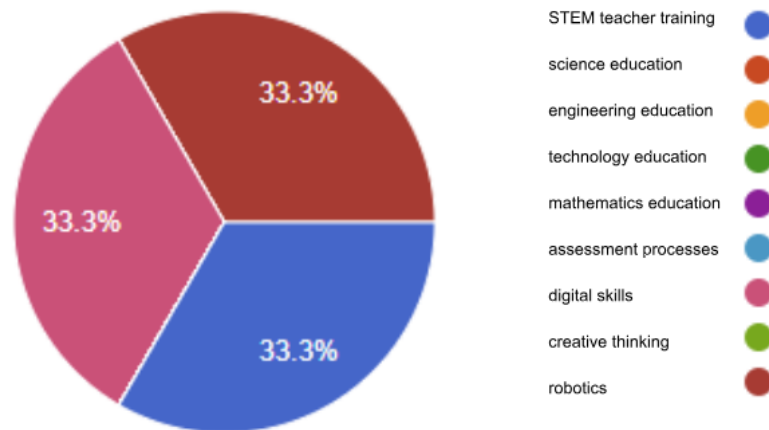


Fig. 6.3.6 Subjects of STEM education research

#### Q4: What's the greatest obstacle in implementing effective STEM education practices?

The greatest obstacles reported by the participants were “lack of educational resources” (N=3), “inadequacy of teachers” (N=2), “Integrating programs across different subjects” (N=2), “insufficient funding” (N=1) and “All the above” (N=1) (Fig. 6.3.7).

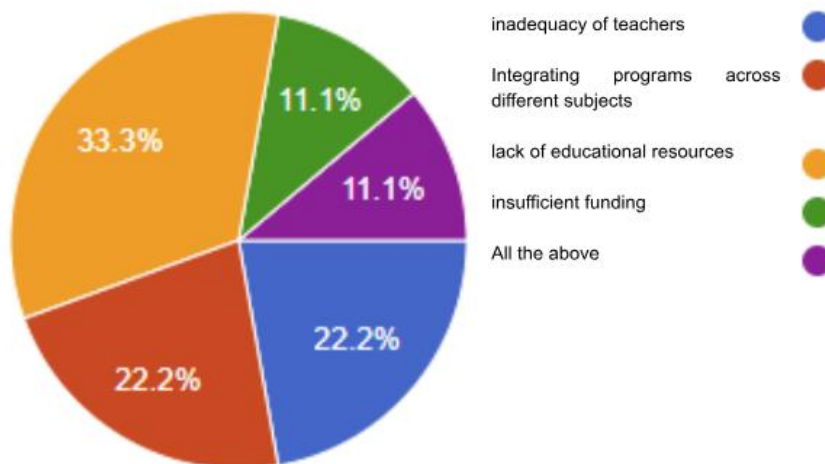


Fig. 6.3.7 Obstacles for effective STEM education practices



**Q5: What are the prominent findings from successful STEM education initiatives**

Reporting on key findings from successful STEM education initiatives the participants outlined “STEM-focused curriculum” (N=3), “use of educational technologies” (N=2), “extracurricular STEM activities” (N=3) and “collaboration projects with the industry” (N=1) (Fig. 6.3.8).

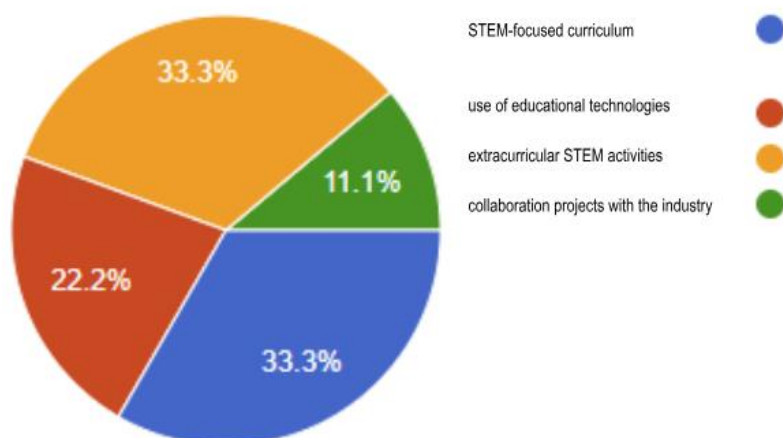


Fig. 6.3.8 Findings from successful STEM education initiatives

## 5.4 Summary

Three exploratory empirical studies were contacted by the Greek research team of “Green STEM” project.

Almost half of the 26 teachers responded that they have taught STEM relate topics, they have followed the integrated STEM education approach, and found their educational material searching in the world wide web. They also mentioned that STEM related teaching contributes to a better understanding of the topics taught.

The majority of the 12 master’s students considered that STEM approach offers them autonomous work and motivation, contributes to better understanding and critical thinking, prepares them for the real life and work, but needs more effort.



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The researchers indicated that there is a need for properly designed training programs for future teachers and in-service teachers.





## 6. Conclusion

Table 6.1 presents various approaches to STEM education appeared during time. These approaches are not strictly separated in time since they are used in parallel. The timeline offers a general view for the evolution of STEM education and its current approach (Bellou & Mikropoulos, 2023).

TERM	DESCRIPTION
S.T.E.M. or S-T-E-M  1980, 1990 decades	Education in STEM fields (Science, Technology, Engineering, Mathematics) Emphasis is given on high level cognitive skills, use of cognitive instructional models (Blackley, & Howell, 2015; Hobbs, Clark, & Plant, 2018: 144).
S.t.e.M.  2000 decade	Emphasis is given on education in the fields of Science and Mathematics. Few references in Technology and Engineering, because they are not autonomous lessons in secondary education, or the terms may be misunderstood.
s.T.E.m.  2000 decade	Emphasis is given on education in the fields of Technology and Engineering. Often met in vocational education. They are seen as disciplines e.g., computer programming and robotics respectively.
STEM Education  2000, 2010 decades	The pedagogical value of STEM education is recognized. The term “integration” appears. Integration indicates the interdisciplinary approach of STEM fields to solve authentic problems (Breiner et al., 2012).
Integrated STEM Education  2000 – 2020 decades	Integrated STEM involves a mainly interdisciplinary approach between two or more STEM fields, and/or between a STEM field and one or more fields beyond the STEM fields (Sanders, 2009). Emphasis is given on “purposeful design and inquiry” (Sanders, 2009).
Integrated STEAM Education	Integrated STEM introduces arts. Arts aim at the enhancement of students’ engagement, the development of innovative ideas and creative thinking,



2000–2020 decades	(Sanders, 2009). Integrated STEM also introduces fields from social sciences and humanities. The term STEAM appears.
Integrated STEM and STEAM Education  2010–2020 decades	Integrated STEM and STEAM Education introduces problems of the real world in the classroom. One or more STEM fields are used to solve real problems. The engineering design process is used to solve real problems. Constructive – learner centered instructional models are used (problem-based learning, inquiry learning, learning by design). (Thibaut et al., 2018). There is a tendency for transdisciplinary approaches.

The present report shows that STEM education in Greece at all educational levels (primary, secondary, tertiary) and types (formal, and non-formal) follows all the approaches presented in table 6.1.

The integrated STEM approach is proposed at the curricula in primary and secondary education. An empirical study conducted by the Institute of Educational Policy, an entity supervised by the Minister of Education, have shown positive results, especially for the development of students' digital and science skills, soft skills, and life skills. Regarding the teachers, they followed cognitive and socio-cognitive instructional models. The main constraints reported by the teachers concern the infrastructures needed to enact STEM educational scenarios, and the long duration of the scenarios proposed by the curricula.

STEM education has been introduced in the tertiary education. There are numerous undergraduate and postgraduate courses offered by Universities in Greece, mainly offered from Education Departments. Several Masters and PhD topics follow the integrated STEM approach, with the majority to refer to a certain topic from the STEM fields.

STEM education is also the topic in many educational, research and development European projects conducted in Greece. Private sector stakeholders collaborate with public schools or Universities in these projects. Most of the projects concern specific STEM fields.

STEM education interests research conducted by Greek researchers. Many studies published concern certain STEM fields, e.g., robotics, and environmental issues. Integrated STEM approaches appear only in few studies. The need of teachers' professional development is highlighted.



Three exploratory empirical studies were contacted in Greece under the “Green STEM” framework. Twenty-six reported that they followed the integrated STEM education approach. They also mentioned that STEM related teaching contributes to a better understanding of the topics taught. Most of the 12 master’s students asked, considered that STEM approach offers them motivation to learn, contributes to better understanding and critical thinking, prepares them for the real life and work. The nine researchers indicated that there is a need for properly designed training programs for both future and in-service teachers.

The report on STEM education in Greece shows that the integrated STEM approach is proposed at all educational levels and is followed at a certain degree. The integrated STEM approach incorporating the engineering design process has to be enhanced. Professional development involving purposeful seminars is needed. Educational scenarios that follow the integrated STEM approach have to be developed.



## References

- Bellou, I., & Mikropoulos, A. (2023). Group and collaborative instructional techniques in tertiary education with the use of digital technology [Undergraduate textbook]. Kallipos, Open Academic Editions. Available at <https://repository.kallipos.gr/handle/11419/9961?&locale=en> (in Greek with abstracts in English).
- Blackley, S., & Howell, J. (2015). A STEM Narrative: 15 Years in the Making. *Australian Journal of Teacher Education*, 40(7), 102-112.
- Breiner, J. M., Johnson, C. C., Sheats Harkness, S., & Koehler, C. M. (2012). What is STEM? A Discussion About Conceptions of STEM in Education and Partnerships. *School Science and Mathematics*, 112(1), 3-11.
- Garcia-Piqueras, M., & Ruiz-Gallardo, J.-R. (2021). Green STEM to Improve Mathematics Proficiency: ESA Mission Space Lab. *Mathematics*, 9(17), 2066.
- Hmelo-Silver, Cindy E. (2004). Problem-based learning: What and how do students learn? *Educational psychology review* 16, 235-266.
- Hobbs, L., Clark, J. C., & Plant, B. (2018). Successful students–STEM program: Teacher learning through a multifaceted vision for STEM education. In R. Jorgensen, & K. Larkin (Eds.), *STEM education in the junior secondary* (pp. 133–168). Singapore: Springer Nature.
- Krajcik, J. S., & Blumenfeld, P. C. (2006). Project-based learning (pp. 317-34).
- Pedaste, M., Mäeots, M., Siiman, L.A., de Jong, T., van Riesen, S. A. N., Kamp, E. T., Manoli, C. C., Zacharia Z. C. & Tsourlidaki, E. (2015) Phases of inquiry based learning: Definitions and the inquiry cycle. *Educational Research Review*, 14, 47-61.
- Sanders, M. (2009). STEM, STEM Education, STEMmania. *The technology teacher*, December/January, 20-27.
- Savery, J. R. (2006) Overview of problem-based learning: Definitions and distinctions. *Interdisciplinary Journal of Problem-Based Learning*, 1(1).
- Thibaut, L., Ceuppens, S., De Loof, H., De Meester, J., Goovaerts, L., Struyf, A., Boeve-de Pauw, J., Dehaene, W., Deprez, J., De Cock, M., Hellinckx, L., Knipprath, H., Langie, G., Struyven, K., Van de Velde, D., Van Petegem, P., & Depaepe, F. (2018). Integrated STEM Education: A Systematic Review of Instructional Practices in Secondary Education. *European Journal of STEM Education*, 3(1), 02.
- Widya, Rifandi, R., Rahmi, Y.L. (2019). STEM education to fulfil the 21st century demand: a literature review. *Journal of Physics: Conference Series*, 1317, 012208
- Wood, D. F. (2003). Problem based learning. *Bmj*, 326(7384), 328-330.
- Yean, A. S., Abdul Rahim S. S. (2021). Greening STEM: A Theoretical Exploration for the Malaysian Context. *Journal of International and Comparative Education*, 10(1). 19-32.

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