



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

WP 2: State of the art analyze and joint strategy development
about Green STEM education practices

Title of the Project:	Green STEM model for teachers' education No. 2022-1-BG01-KA220-HED-000088567
Leading organization	BULGARIA - SOUTH-WEST UNIVERSITY NEOFIT RILSKI BLAGOEVGRAD
Name of the Reporter Partner	University of Ioannina, Greece
Nationality of Reporter Partner	GREECE



Contents

1	STEM education.....	3
2	The state of STEM education in Greece	5
2.1	STEM education in elementary and secondary education.....	5
2.1.1	Skills Labs.....	5
2.1.2	The “Technology” lesson in junior high school	10
2.1.3	Summary.....	11
2.2	STEM education in higher education	13
2.2.1	University Undergraduate Curricula at Departments of Education.....	13
2.2.2	Master’s programs	14
2.2.3	Master and PhD theses on STEM	15
2.2.4	Summary	39
3	Projects.....	40
3.1	HORIZON 2020 projects.....	40
3.2	Erasmus+ projects	42
3.3	e-Twinning programs, seminars, and summer schools.....	45
3.4	Summary	47
4	Research results from Greek researchers	48
4.1	Conference papers	48
4.1.1	Hellenic Scientific Association of Information & Communication Technologies in Education (www.etpe.gr)	48
4.1.2	Association for Science Education and Technology (http://www.enephet.gr)	56
4.2	Indicative journal publications or book chapters.....	61
4.3	Summary	69
5	Empirical studies	71
5.1	Teachers’ attitudes.....	71
5.2	Postgraduate students’ opinions	75
5.3	Researchers’ opinions	83
5.4	Summary	86
6	Conclusion	88
	References.....	90



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 21st 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 placed-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, 21st 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 1st Primary)
- "STEM and the Earth turns" (Kindergarten)
- "Phenomena in the Nanocosm" (5th, 6th Primary)
- "Electric current you are "accused" of..." (5th, 6th Primary)
- "First time godparents" (5th, 6th Primary)
- "Robots at the service of recycling" (Kindergarten, 1st, 2nd Primary)
- "The power of the lever and the example of the catapult. The role of leverage in the human-made environment" (5th Primary)
- "Transformations of geometric shapes and solids" (5th Primary)
- "We create buildings friendly to the environment and people" (5th, 6th Primary)
- "Seasons and Climate" (5th Primary)
- "Stop motion animation: When pictures move" (4th, 5th, 6th Primary)
- "Digital literacy: Creative and safe internet" (5th, 6th Primary, 1st high school)
- "Digital Intelligence: Adapting to the modern digital world" (5th, 6th Primary, 1st high school)
- "We're designing a robot" (4th, 5th, 6th Primary)
- "I'm becoming a creator of my schoolyard!" (all grades of the Primary School)
- "My pencil case" (introduction to 3D design and printing)" (1st, 2nd, 3rd high school)
- "Promoting learning through art" (1st, 2nd, 3rd high school)
- "Creating a story/game using Scratch" (2nd year high school)
- "Robotics with Arduino" (2nd, 3rd high school)
- "Greenhouses, combining nature with technology" (1st, 2nd grade high school)
- "3D printing with the help of tinkercad" (2nd grade high school)
- "The world of interior architecture and decoration with Homestyler" (2nd, 3rd grade high school)
- "The earth is not flat (everything flows) - Newtonian mechanics" (2nd 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" (2nd grade high school)
- "Artificial Intelligence" (1st, 2nd high school)
- "I'm learning to learn: I'm talking to myself... and I'm right!" (1st, 2nd, 3rd high school)
- "Designing the smart school" (1st and 2nd grade high school)
- "The Hidden Message Game" (1st and 2nd year high school).

The organization programs include the following topics:

- "Little Meteorologists" (Kindergarten and 1st, 2nd, Primary)



- "European School Radio, The First Student Radio" (Kindergarten, Primary and High School)
- "ELEPHYS - Illustrated Physics Dictionary for School" (5th, 6th Primary and 1st and 2nd high school)
- "STE(A)M and Educational Robotics through the Water cycle and Hydrodynamics" (Kindergarten and 1s1st Primary)
- "Heroes of the World" (3rd, 4th, 5th Primary)
- "TV Literacy Activities" (3rd – 6th Primary and 1st – 3rd High School)
- "Materials for a Sustainable Future" (1st, 2nd, 3rd High School)
- "Study Program for STEAM" (2nd – 6th Primary, 1st – 3rd High School)
- "Digital Humanities" (1st, 2nd, 3rd High School)
- "The School Class Meets the Scientist" (4th – 6th Primary)
- "Tomorrow's Scientists and Engineers" (6th Primary and 1st, 2nd, 3rd High School)
- "First Lego League Jr" (1st – 4th Primary)
- "Safe Internet Use Guides" (1st – 6th Primary and 1st, 2nd, 3rd High School)
- "Schools Study Earthquakes – The SNAC Platform" (1st, 2nd, 3rd High School)
- "EnvStories Platform (Kindergarten, 1st - 6th Primary)
- "Educational Robotics in Kindergarten Activity Labs" (Kindergarten)
- "Discovering STEAM" (Kindergarten, 1st – 6th Primary and 1st, 2nd, 3rd High School)
- "Educational Robotics in Elementary School Activity Labs" (1st – 6th Primary)
- "Educational Robotics in High School Activity Labs" (1st, 2nd, 3rd High School)
- "'The lesson... game!' An Educational Guide to Designing Tabletop and Digital Narrative Games" (1st – 6th Primary and 1st, 2nd, 3rd High School)
- "Teaching spatial thinking" (1st – 6th Primary and 1st, 2nd, 3rd High School)
- "Robotics and STEAM FLL Program" (Kindergarten, 1st – 6th Primary and 1st, 2nd, 3rd High School)
- "Young researchers interpret their environment with Web GIS technology " (1st, 2nd, 3rd High School)
- "SKILLS LABS implemented even in school units with rudimentary equipment" (Kindergarten, Primary, High School)
- "App Your School" (5th, 6th Primary, 1st, 2nd, 3rd High School)
- "STEAMulate Your School" (5th, 6th Primary, 1st, 2nd, 3rd High School)
- "Empowering Girls in Steam Education through Robotics and Programming" (Primary, High School)
- "Chess and Imagination" (Kindergarten and 1st, 2nd Primary)
- "Chess, a game of strategy and Math, a game for everyone!" (4th, 5th, 6th Primary)
- "Protecting our forests" (5th 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 21st 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.



**Co-funded by
the European Union**



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 human health. 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 second grade of High School 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 Astronomy in 39 elementary school 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</p>	<p>Inquiry-based educational approaches lead, mostly, in positive student results. Although these approaches can</p>



<p>teaching of photosynthesis through inquiry.</p>	<p>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, 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 photosynthesis teaching, through inquiry-based educational methods. The study sample is consisted of 92 second-grade high-school students, 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>
<p>Construction and Teaching Use of the Hydrobot by Future Teachers, in the Context of a STEM Education Aiming at Scientific Literacy</p>	<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 future teachers were able to propose ways of incorporating Hydrobot in teaching, in order to fulfill scientific literacy's 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 middle school understand the meaning of hydrostatic pressure and buoyancy 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</p>



	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.
--	--

Table 2.2.3.2 STEM relevant Master theses, Year 2019	
Title	Short Abstract
Future preschool and primary school teachers' perceptions about educational robotics and STEM	The present study investigates the attitudes of future pre-school and primary school education teachers , 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 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 educational robotics . 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.
Educational robotics as a factor in changing students' attitudes towards STEM sciences: parents' assessments	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.



The project of educational robotics as a means of supporting the joint educational process of two different classes in a small school.	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 Mathematics in a small school.
An investigation of teacher's perceptions about gender and STEM	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 gender and STEM , focusing on the role of education and more specifically, on the teacher / educator. The present study therefore deals with primary school teachers 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.

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	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 special learning difficulties 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 teaching of physics vocabulary and the STEM/STEAM educational policy.
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, students' attitudes, opinions and behaviors towards STEM sciences and STIMEY were studied before and after the teaching intervention with the help of the STIMEY robot. In this context, it was investigated what attitude Middle and High School students have towards STEM and robotics. At a second 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>
The impact of the use of 3D Printing technology on content knowledge, stress and student's interest in the Natural Sciences	<p>The present study examines the results of the effect of a project done by students of the 5th and 6th grade of Primary School with the use of 3D Printing Technology on content knowledge, anxiety and their interest in natural sciences 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 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 5th grade. The main goal of this research is to design, implement and evaluate a teaching intervention for Physics 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 sexes. However, students' feelings about this intervention were joy and excitement.</p>
<p>Comparative study of the presence of astronomy in the primary education curricula of 17 countries from 5 continents</p>	<p>The purpose of this study is to conduct a comparative analysis between science curricula for primary school from 17 countries (including countries from 5 different continents) regarding the subject of astronomy. 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>
<p>Leveraging the Arduino Platform in Education: Designing Learning Activities Based on the ECLiP Framework</p>	<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 primary and secondary education. 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</p>



	educational robotics activities and exploiting alternative programming 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 Informatics ". 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 Computer Science , 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 secondary education . 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
Utilization of the STIMEY Program Social Assistance Robot and the STIMEY Program Online Platform for Teaching Astronomy Courses	As part of this research, an astronomy course was taught using the STIMEY program "Social Science" robot and the STIMEY program platform to 6th grade 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.
Teaching weather phenomena in the early years of primary school with digital applications	A study with twenty 8-year-old pupils has been carried out aiming to help children understand weather phenomena , meteorological symbols and forecasts, as well as contribute



	<p>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, 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>
e-STEEM: A design of online lessons based on inquiry learning for science teaching	<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 Science and was addressed to students of the fifth and sixth grade 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>
Studying changes on the Earth’s surface with the use of satellite imagery: A teaching proposal for primary education	<p>The purpose of this thesis was to create a comprehensive teaching proposal for Primary School about the changes on the Earth's surface, a subject included in the Curriculum of Geography. 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 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</p>



	<p>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 Mathematics in Primary education. 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 Physics. 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 4th grade students in primary school in the context of the interdisciplinary course of Environmental Education. For the 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 high school students that put into practice the STEM teaching model. On the occasion of making measurements for different atmospheric quantities, the teacher has the opportunity to combine elements from different scientific</p>



	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 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 Primary Education , specifically to Environmental education . 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
The impact of STEM on mathematics in early childhood education	<p>The questions of this study were the following:</p> <ul style="list-style-type: none"> • What math skills do children develop with STEM instruction? • What are the benefits to children's math skills through STEM instruction? <p>A model for teaching mathematics to preschool 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 vocational high schools. 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 in-service teachers 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. 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 the curriculum through the STE(A)M approach</p>	<p>The emphasis given to the increase of interest and the motivation of the students' involvement was a trigger for the use of the specific method in preschool education, to observe an increase or not, in the active participation of preschoolers in the Analytical Curriculum of the</p>



	<p>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.</p>
Teacher's attitude towards S.T.E.M in secondary education	<p>The main purpose of this study was to examine the level of secondary education teachers' 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.</p>
The role of digital applications to self-perceived student's content knowledge from Departments of Science, Technology, Engineering and Mathematics (STEM) and self-confidence for employment	<p>This thesis studies the impact of digital applications in 2 main fields, self-perceived content knowledge of university students 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.</p>
The creative thinking of children of early school age, through STEAM activities	<p>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 kindergarten, A-B and mainly third grade primary school. 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</p>



	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 Elementary Education as a part of the Informatics Class. For this purpose, ten programming activities based on Arduino 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.
Utilization of the internet of things (IoT) for creative stem education	This paper proposes the use of IoT in STEM education for students of the last grades of Primary Schools 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.
Design and Implementation of Interdisciplinary Teaching Activities: leveraging STEM approaches to teach programming in the school unit	This postgraduate thesis presents the implementation of seven laboratory cycles of a skills program with the ultimate goal of acquiring basic programming skills in a playful way through the Scratch visual programming environment, for High School students , 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 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.



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 high school students in Greece. The case study concerned the physics 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 – 2.2.3.11.

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	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 program robotic 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 the most appropriate was



	<p>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.</p>
--	--

Table 2.2.3.8 STEM relevant PhD theses, Year 2020	
Title	Short Abstract
Cinema art and technique through virtual learning environments: machinima case in the Greek educational system	<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</p>



	<p>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 film education. 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 as the starting point for discussing the application of machinima in the school curriculum in various educational subjects.</p>
--	---

Table 2.2.3.9 STEM relevant PhD theses, Year 2021	
Title	Short Abstract
<p>Playful interactive storytelling as a method of transmission of cultural content</p>	<p>The subject area of this thesis concerned the use of serious games in the domain of cultural heritage. 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 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</p>



	<p>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 teenage and adult participants 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>
Augmented Reality in Secondary Education in the field of STEM: a case study with schoolteachers in Cyprus and Greece	<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 supported interventions. Through the discussion and</p>



	<p>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>
--	--

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	<p>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 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</p>



	<p>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 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 secondary education schools. 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 Chemistry 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 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</p>



	<p>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 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	STEM-based education faces several challenges when implementing it in practice since it requires the existence of an organized environment, the necessary logistical



<p>action research findings for STEM education and educational robotics</p>	<p>infrastructure (robotics - STEM educational 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.</p>
<p>An open hardware mechanism for remote delivery of laboratory activities in science, STEAM, and educational robotics environments: development, usability, and technology acceptance among educators</p>	<p>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 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>

Table 2.2.3.11 STEM relevant PhD theses, Year 2023



Title	Short Abstract
The use of drones in education in the context of mobile learning and STEM education	<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 primary and secondary education teachers 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-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 Physics 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-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</p>



	<p>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 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>
Interactivity and learning: the integration of robotics competitions into the educational process: design, implementation, evaluation	<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</p>



	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 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.
--	--

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*

“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 DAISSy (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/

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

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.



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)

7th 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.

12th 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., Xefteris, 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., & Rentzepi, 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 12th 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 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.

6th 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.

9th 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.

11th 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 taleand 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., & Tsolopiani, 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.enephet.gr>)

13th 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., & Vavougiou, 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.

12th National conference. The role of science education in community of 21st 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., & Tsalmipouris, 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.

11th 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).

10th 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

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

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

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 STEMPCK 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 STEMPCK scores of Greek and Turkish preschool teachers. The significant differentiation of STEMPCK 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

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)

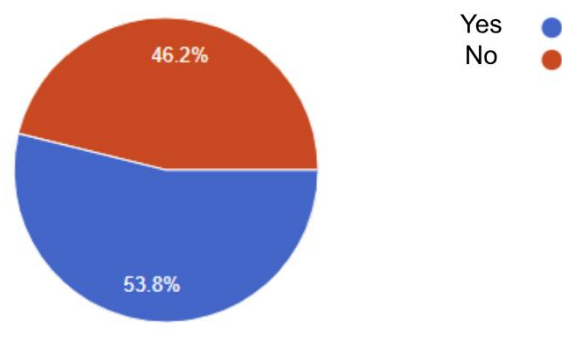


Fig 6.1.1: Distribution of Opinions: teaching STEM-related subjects

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).

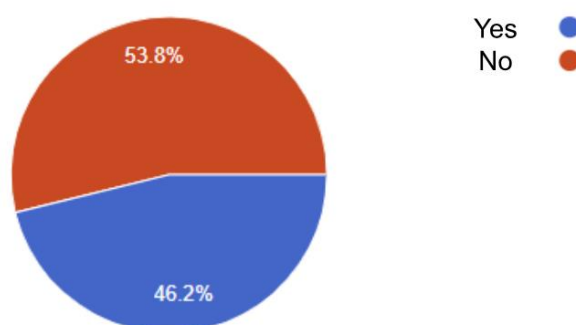


Fig 6.1.2: Distribution of Opinions: following the integrated STEM approach

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).

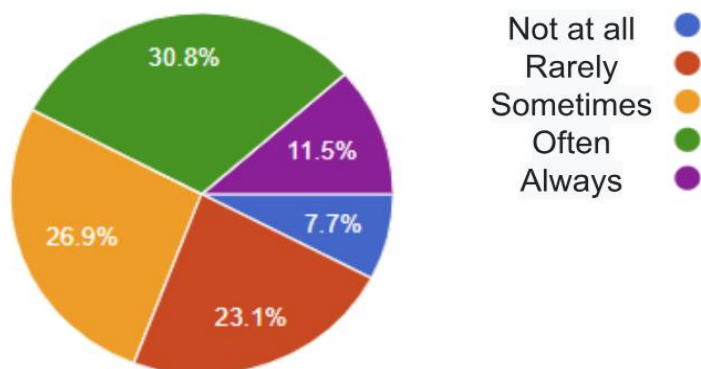


Fig 6.1.3: Use of audio-visual materials

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).

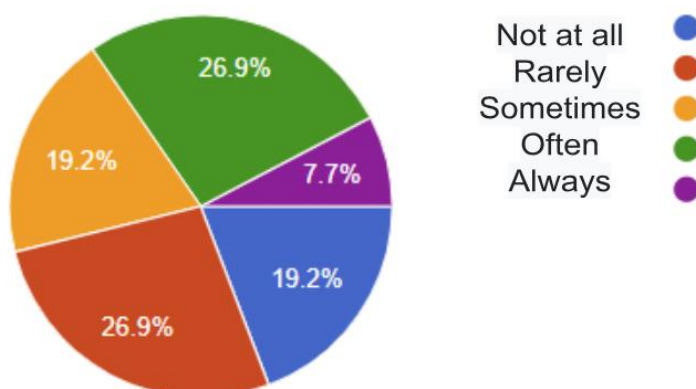


Fig 6.1.4: Use of STEM-specific software

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., Scintix), 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)

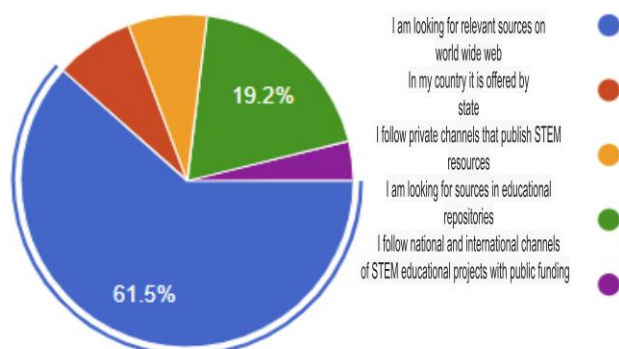


Fig 6.1.5: Sources of educational materials

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)

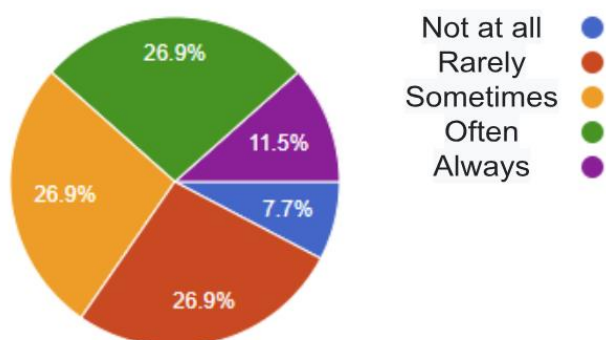


Fig 6.1.6: Inadequate technical assistance affecting STEM teaching

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)

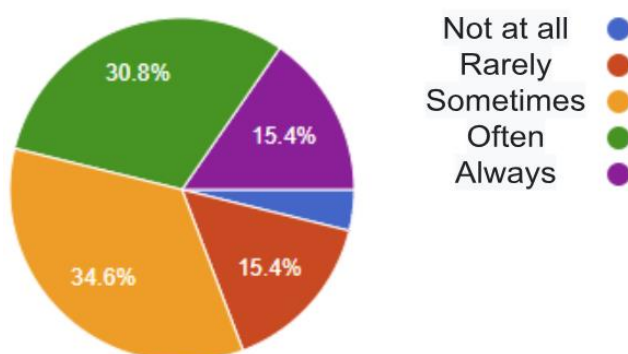


Fig 6.1.7: Lack of material in Greek affecting STEM teaching

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)

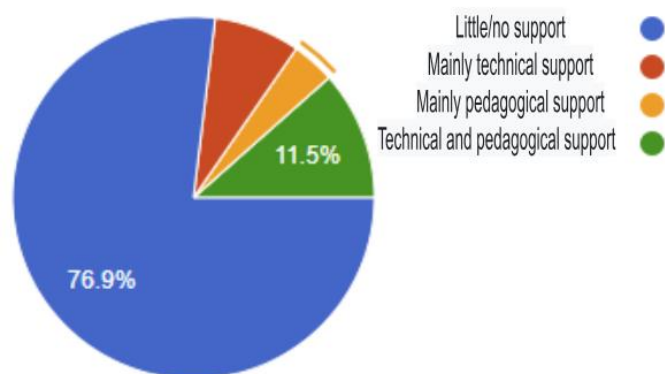


Fig 6.1.8: Support provided

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)

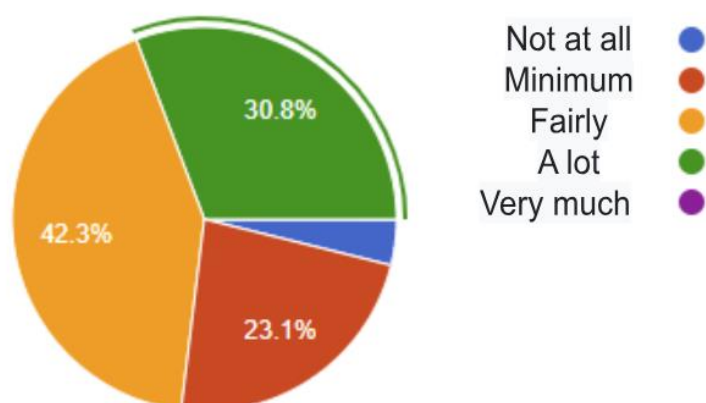


Fig 6.1.9: Opinions on positive effects on making students work harder

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)

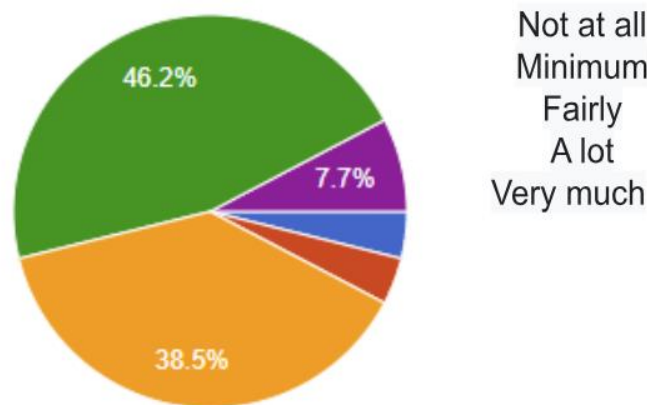


Fig 6.1.10: Opinions on positive effects on students' better understanding

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).

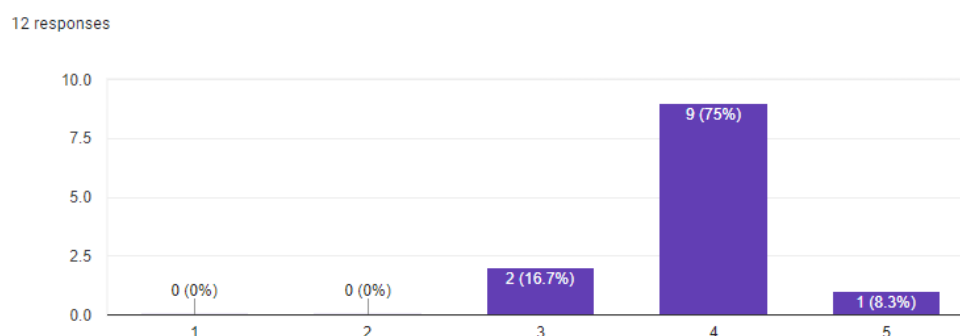


Fig 6.2.1 Opinions about STEMs' impact on concentration

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).

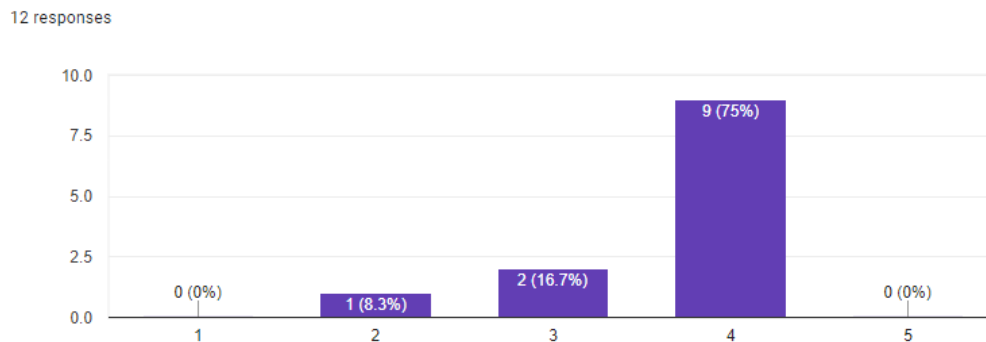


Fig 6.2.2 Opinions about STEMs’ impact on effort

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).

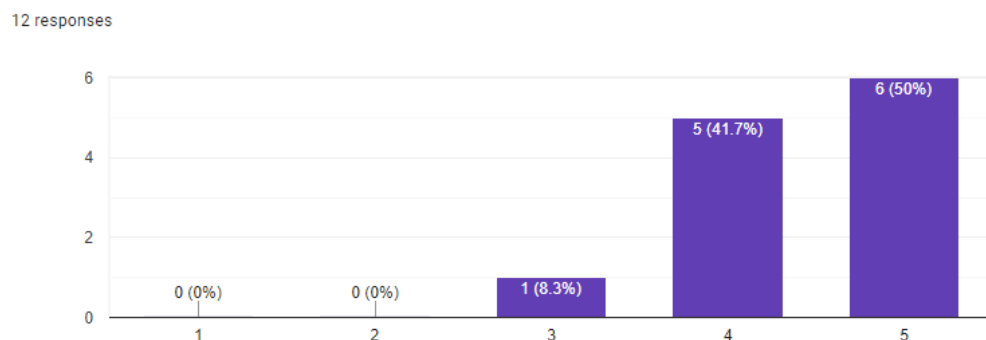


Fig 6.2.3 Opinions about STEMs’ impact on autonomy

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).

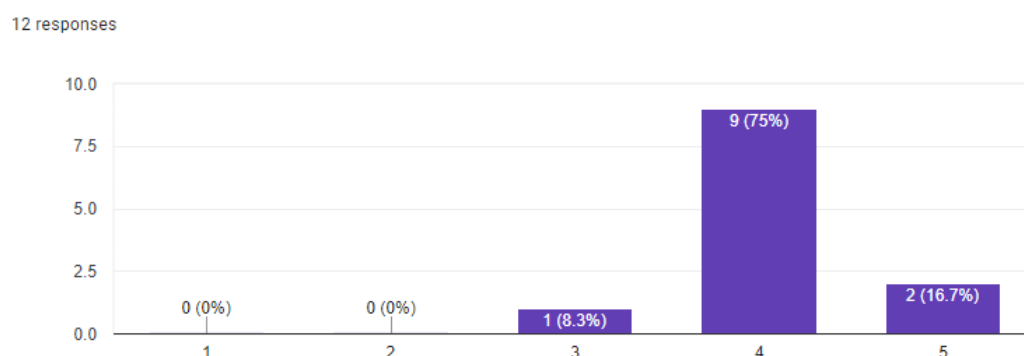


Fig 6.2.4 Opinions about STEMs’ impact on understanding

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).

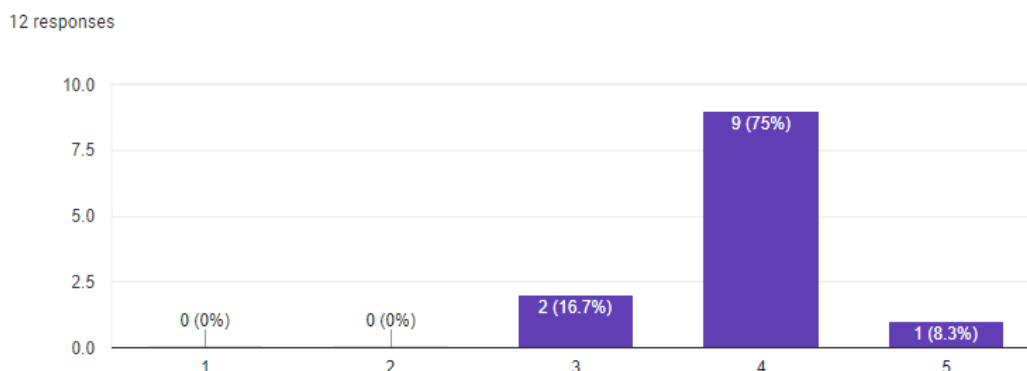


Fig 6.2.5 Opinions about STEMS' impact on memory

1.6 Students develop critical thinking

Two participants answered “Very much”, nine “A lot” and one answered “Enough” (Fig 6.2.6).

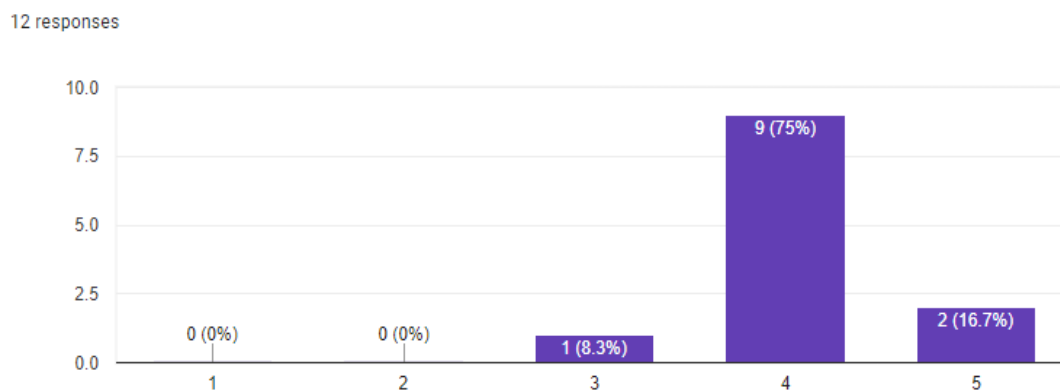


Fig 6.2.6 Opinions about STEMS' impact on critical thinking

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

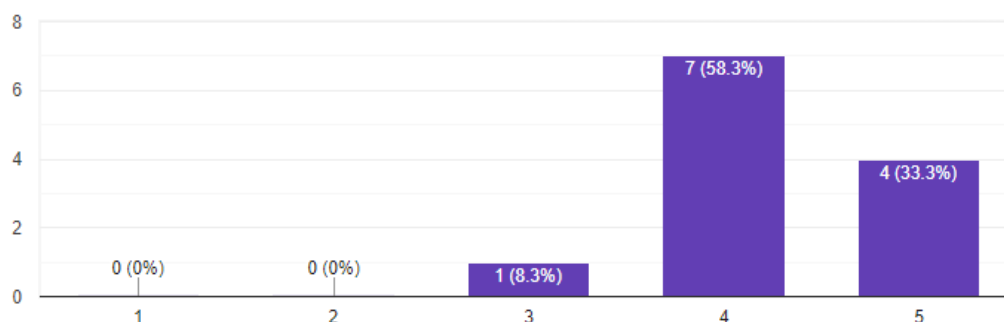


Fig 6.2.7 Opinions about STEMs' impact on interest in STEM careers

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

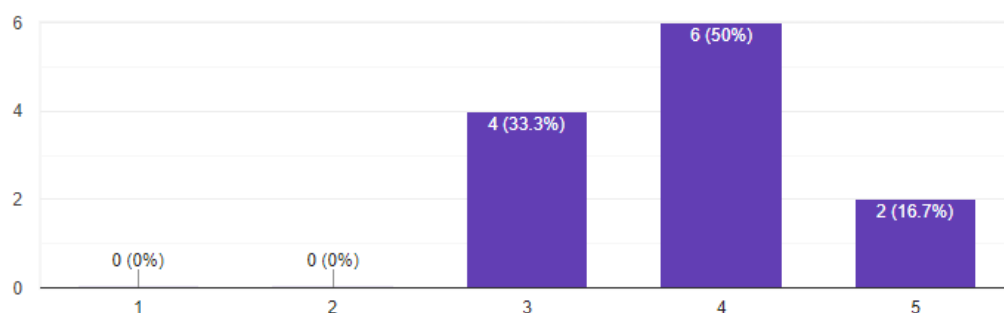


Fig 6.2.8 Opinions about STEMs' impact on collaborative work

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

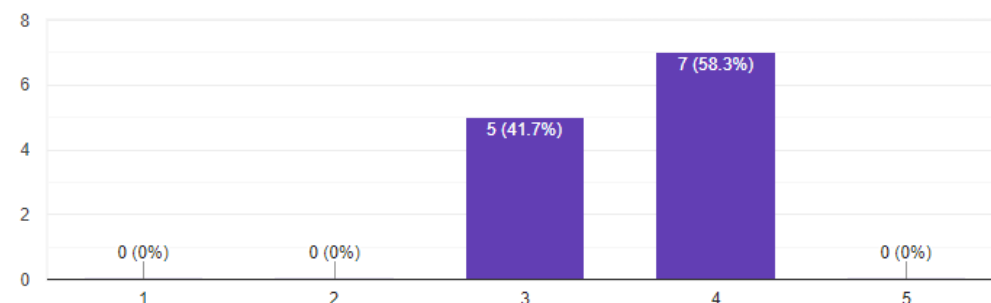


Fig 6.2.9 Opinions about STEMs' impact on classroom climate

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).

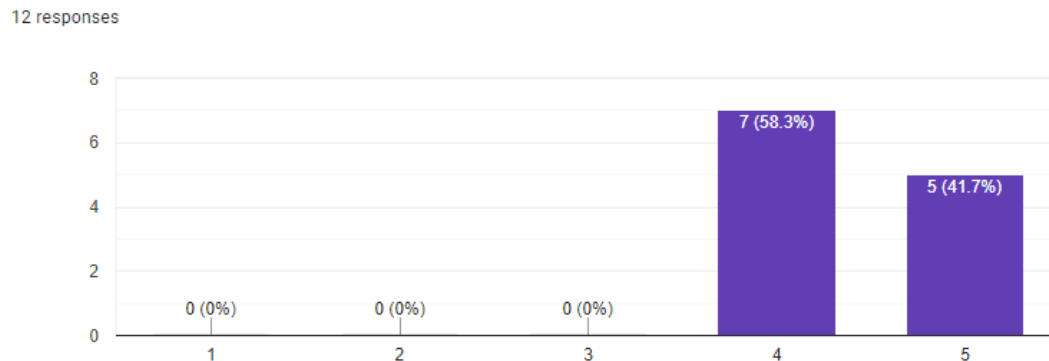


Fig 6.2.10 Opinions about ICT's use to do exercises and practice

2.2 retrieve information

Seven of the participants totally agree, four agree and one is neutral (Fig 6.2.11).

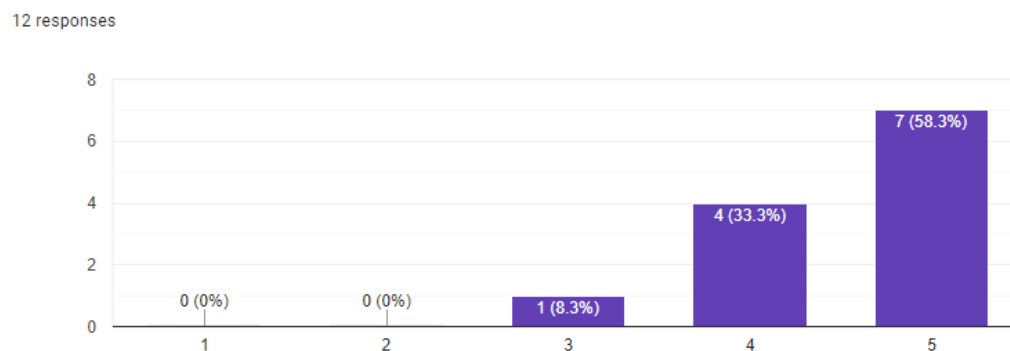


Fig 6.2.11

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).

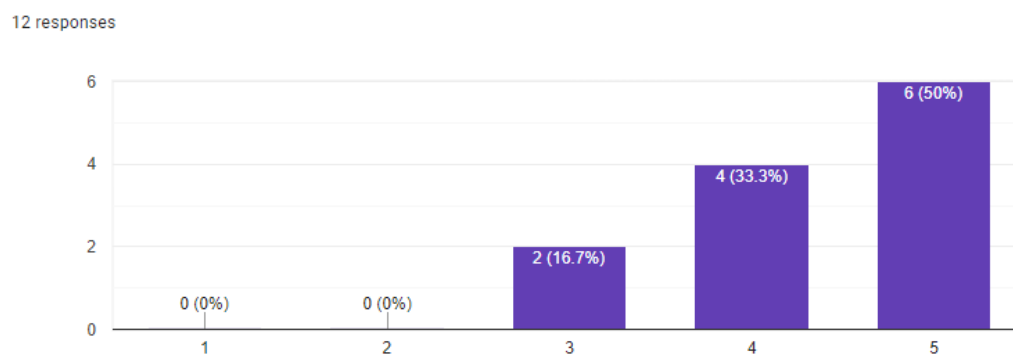


Fig 6.2.12 Opinions about ICT's use to work cooperatively



2.4 learn in an autonomous way

Five students totally agree and seven agree (Fig 6.2.13).

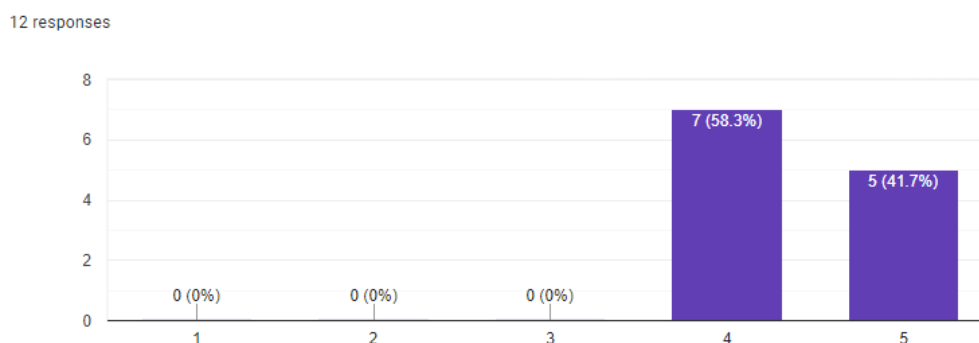


Fig 6.2.13 Opinions about ICT's use to learn in an autonomous way

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).

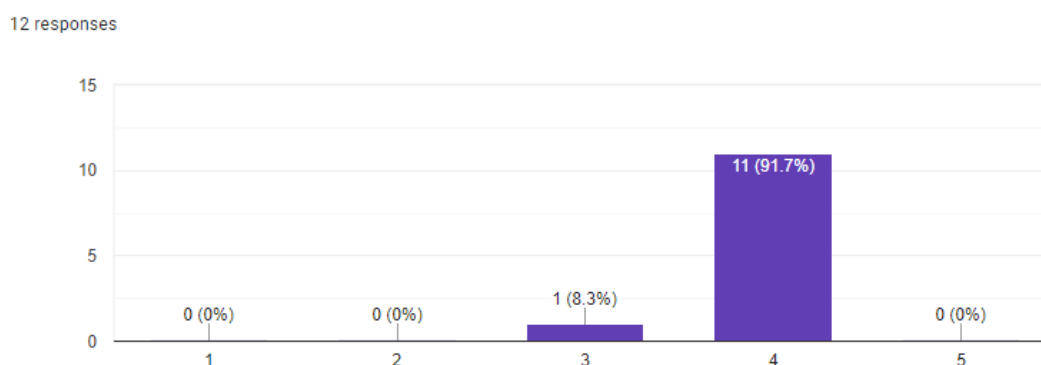


Fig 6.2.14 Opinions about ICT effect on students' internal motivation

3.2 Student achievements

Two of the participants totally agree, seven agree and three are neutral (Fig 6.2.15).

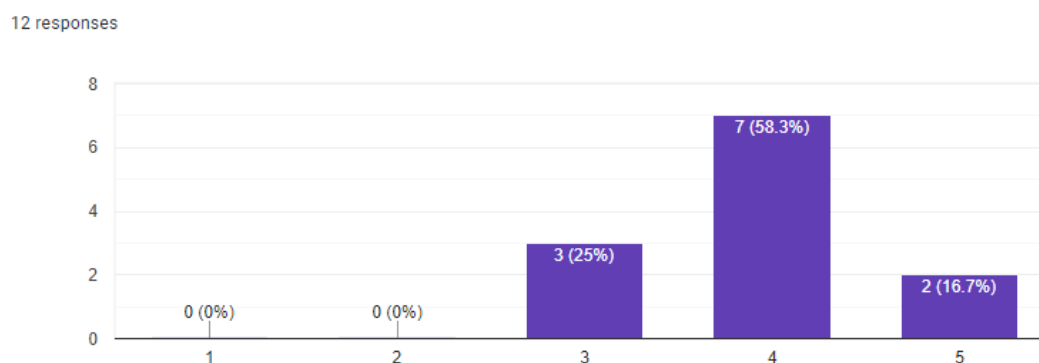


Fig 6.2.15 Opinions about ICT effect on students' achievements

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

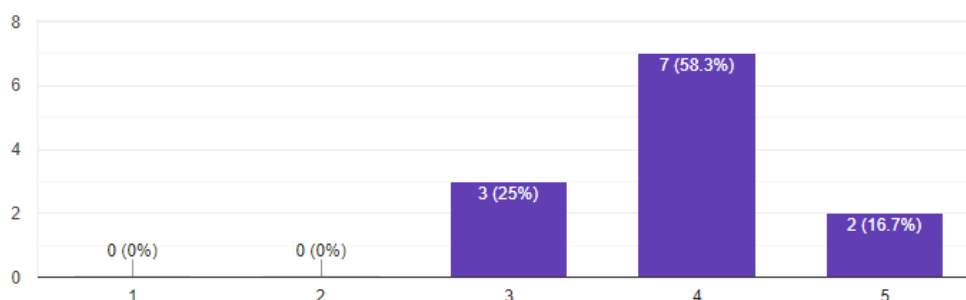


Fig 6.2.16 Opinions about ICT effect on Higher-level skills

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

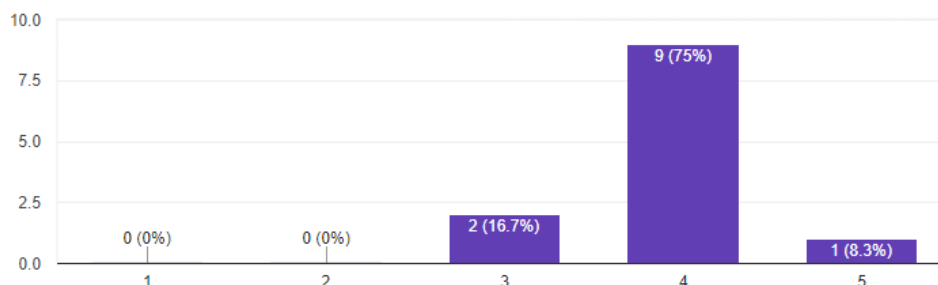


Fig 6.2.17 Opinions about ICT effect on transversal skills

Q4: The use of ICT in teaching and learning is essential for students to be properly prepared for life and work in the 21st century (Totally disagree – Totally agree)

Five students totally agree and seven agree (Fig 6.2.18)



12 responses

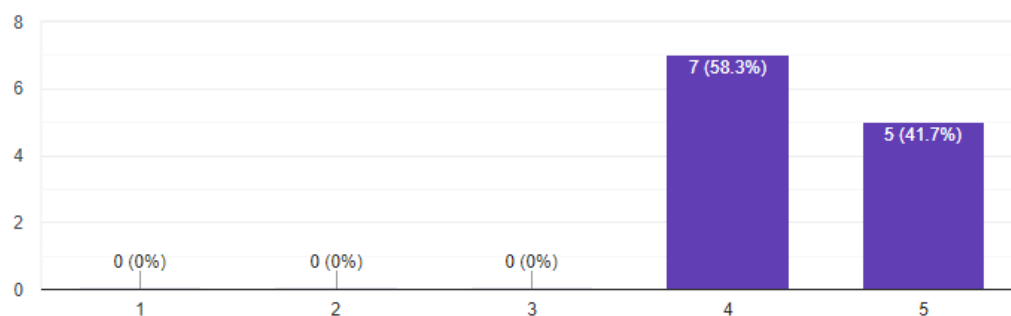


Fig 6.2.18 4 Opinions about ICT's usage in teaching and learning impact on students' preparation for life and work

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).

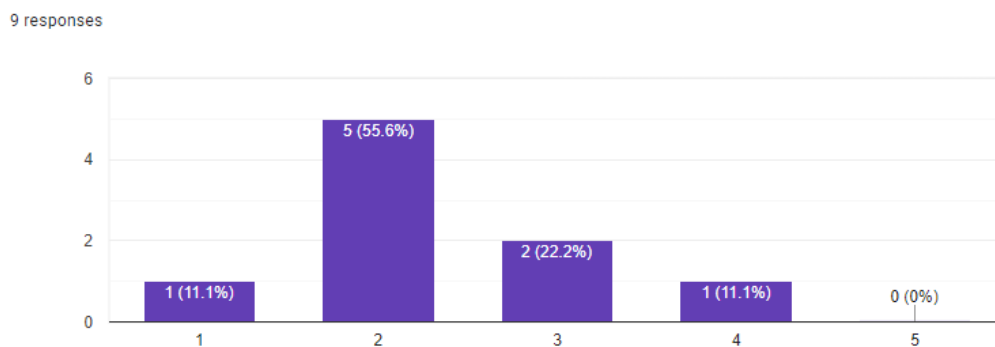


Fig. 6.3.1 Situation regarding STEM education in your country

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).

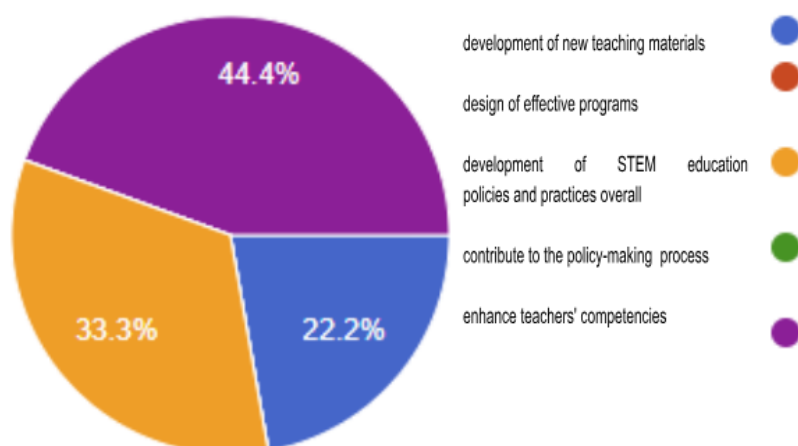


Fig. 6.3.2 Ways of contribution to the improvement of STEM education

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).

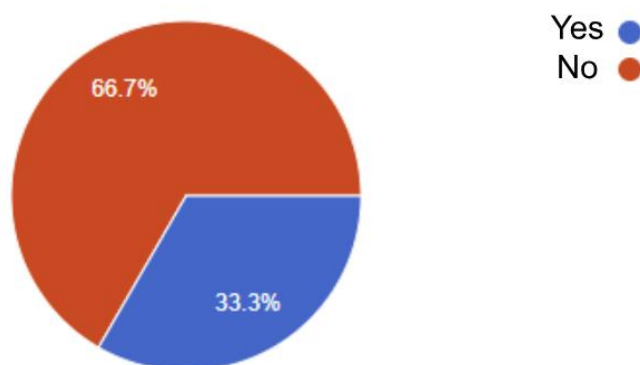


Fig. 6.3.3 Participation in STEM education research

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).

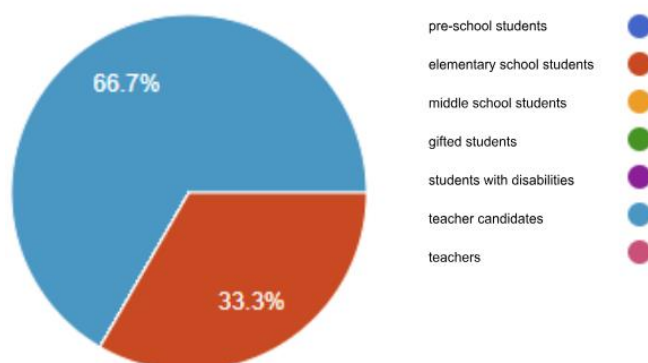


Fig. 6.3.4 Participants in STEM education research

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).

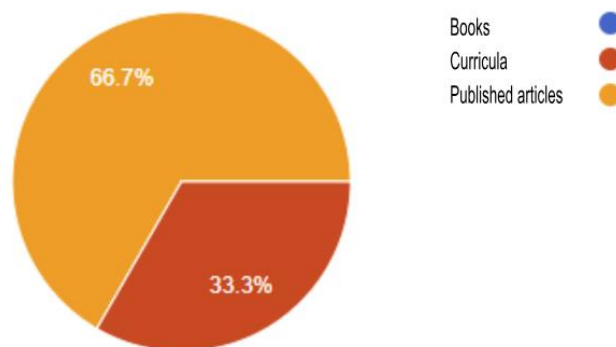


Fig. 6.3.5 Sources for STEM education research

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).

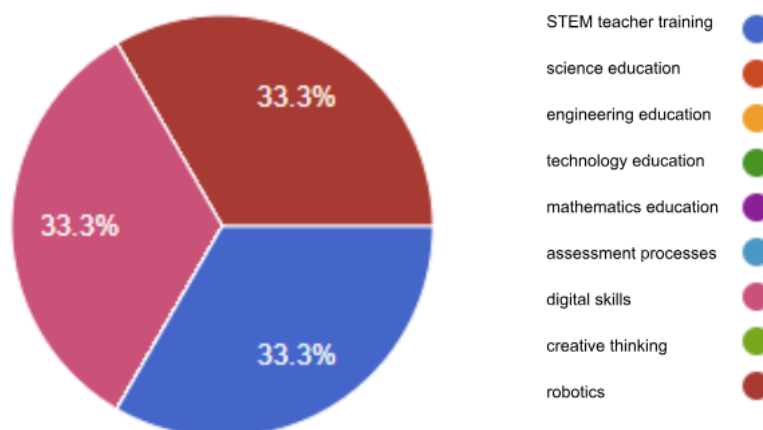


Fig. 6.3.6 Subjects of STEM education research

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).

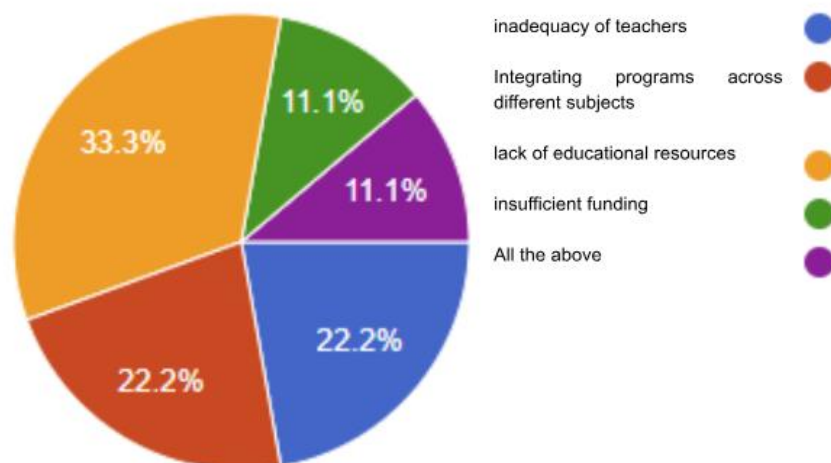


Fig. 6.3.7 Obstacles for effective STEM education practices

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).

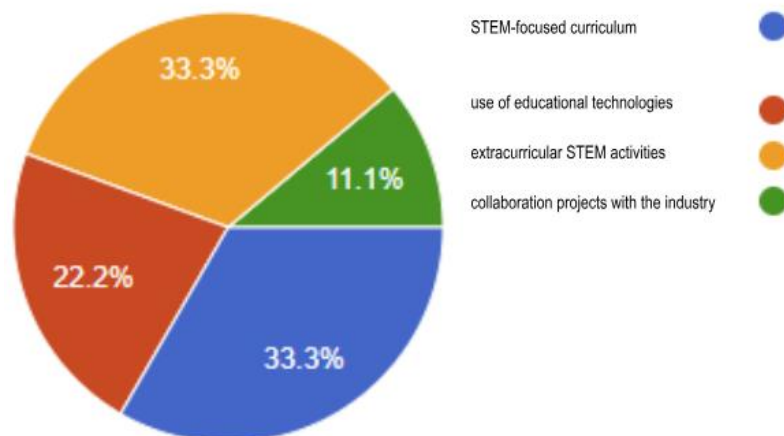


Fig. 6.3.8 Findings from successful STEM education initiatives

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.

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 2000–2020 decades	Integrated STEM introduces arts. Arts aim at the enhancement of students’ engagement, the development of innovative ideas and creative thinking, (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.

