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IO1 - Research on STEM Education

Final report

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Table of Contents

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Introduction

The STEM Education Platform (SAPPHIRE) project focuses on the development of a shared, online space for youth students and educators, which will accommodate innovative pedagogical approaches, tools, learning material and courses for professional development. Moreover, the STEM platform will encourage users to exchange ideas and work together within a community. In the framework of IO1 "Research on STEM education", a case study in STEM education was conducted in each partner country: Bulgaria, Republic of North Macedonia, Lithuania, Cyprus, Portugal, Italy, and Greece. Despite the fact that Intellectual Output 1 was cut from the final project budget, partners decided to proceed with small-scale research, since the collected data would be valuable for the development of the STEM education platform in Intellectual output 2.

The research aimed at mapping the current situation in STEM education in all the participating countries. Each case study included both primary and secondary data. In particular, the desk research was a brief overview of STEM education in each country accompanied with STEM practices implemented at a national level. For the field research, an online survey was distributed online, targeting STEM teachers, trainers and experts. The survey consisted of three demographic questions (participant's background, whether or not they teach STEM lessons at the moment and if professional development training in the STEM field is compulsory in each country), four Likert scale questions (1= Not at all, 2=Not really, 3=Undecided, 4=Somewhat, Very much=5) in regards to the use of educational innovations and a multiple choice question, asking participants about the learning resources they have or they would like to have at their disposal. The survey concluded with an open-ended question which enabled participants to mention what further support they might be needed in a STEM lesson. Partners analyzed the feedback received from the survey and outlined the main outcomes in chapter 2. In chapter 3, the findings were summarized and each partner drew conclusions about STEM education in their country.

In the following sections, the case of each partner country will be analyzed and the main findings will be discussed. The conclusion will summarize the outcomes.

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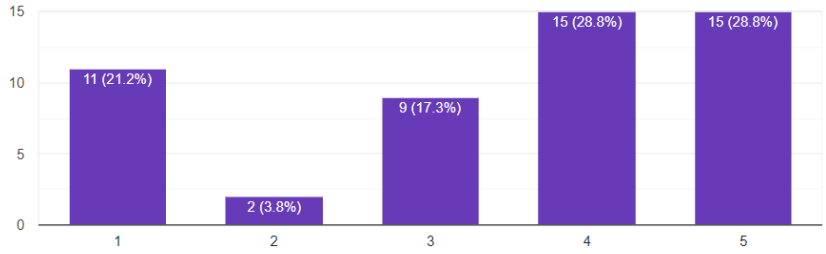
National results per country

The case of Bulgaria

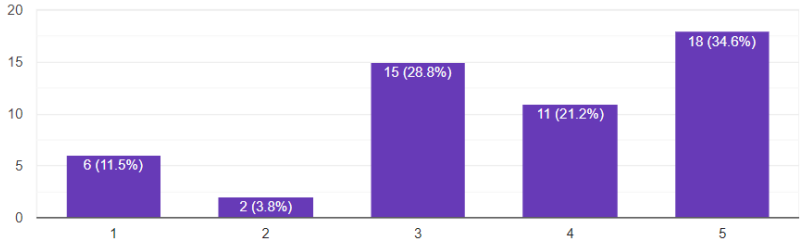
In recent years, Bulgaria has started reforming the education system. The changes focus on the active role of teachers in the learning process and emphasizes on the need for the development of STEM competences for both educators and students. Since IT is a fast growing sector, it requires qualified personnel. Providing the proper education to students enables the professional and personal growth of the country in the future. A national programme (Building a school STEM environment) is planned to be implemented to increase students' interest and their achievements in the field of STEM and a STEAM journal disseminate good practices and empirical evidence.

According to the survey, 52 responses were recorded from STEM teachers, trainers, researchers and explorers. More than half of the respondents stated that they use educational innovations (e.g. toolkits, applications, digital platforms, new methodologies, programs etc.) in STEM lessons while the vast majority support the state that educational innovations can support STEM –related lessons (44.2%= "Very much", 21.2% = "Somewhat", 17,3% = "Undecided").



Graph 1. The use of educational technologies in STEM lessons

Furthermore, 34.6% of the participants believe that educational innovations help them very much improve their monitoring and assessment of student's learning in STEM lessons (11 = "Somewhat", 15= "Undecided") and they are capable of improving the teaching process (18= "Very much", 13= "Somewhat", 12 = "Undecided").



Graph 2. The use of educational technologies for monitoring and assessing student's learning

In regards to the learning resources/material they would like to use, but do not have at their disposal, web-based and computer-based systems (53.8%), Augmented/Virtual reality tools (46.2%) and resources for personalized learning (42.3%) concentrated the vast majority of the responses. As a further support, educators need facilities, technical resources, e-learning platforms, training/courses, resources/material.

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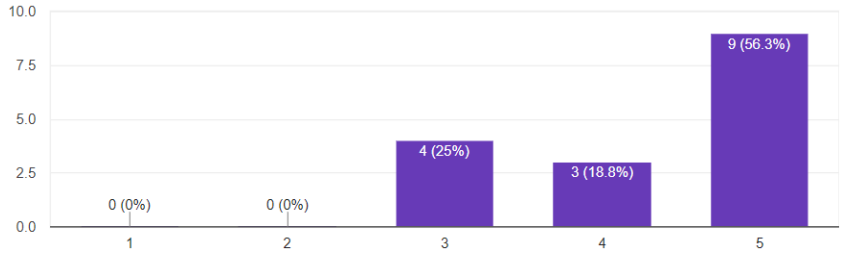
The case of North Republic of Macedonia

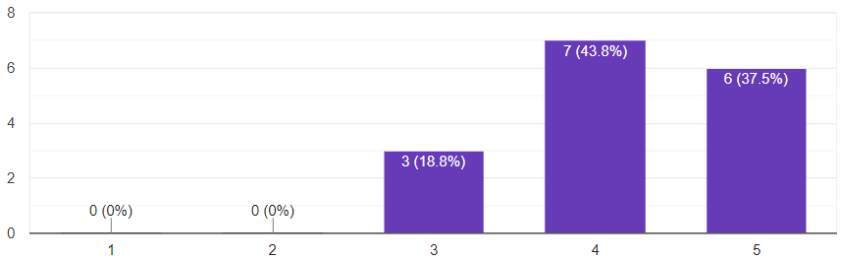
The educational system in North Macedonia has made reforms in the curriculum in order to promote innovation in STEM such as the integration of different methodologies and technological tools in the teaching practice. However, more structured STEM activities are required to increase student's motivation.

According to the survey, 16 responses were recorded from STEM teachers, experts, trainers and researchers. More than half of the respondents (56%) use educational innovations (e.g. toolkits, applications, digital platforms, new methodologies, programs etc.) in STEM related lessons. Also, over 56% answered that to a great extent the educational innovations help them to improve their teaching and learning processes in STEM lessons.



Graph 3. The use of educational technologies for monitoring and assessing student's learning

Furthermore, the vast majority of the participants believe that educational technologies help them improve their monitoring and assessment of student's learning in STEM lesson (6= "Very much", 7= "Somewhat", 3= "Undecided") and they are capable of improving the teaching process (5= "Very much", 9= "Somewhat").



Graph 4. The use of educational technologies for monitoring and assessing student's learning

In regards to the Learning resources/material they would like to use, but do not have at their disposal, STEM software (9) and resources for personalized learning (7) recorded the most responses. Some responses were recorded in robots, sensors, data loggers, experimental laboratories. In general, some schools do not have access to the basic learning aids such as computers and the internet. As a further support, participants mentioned that they would like to have experimental labs, practical experience, robots, laptops and internet connection. The majority of them stated that they need STEM professionals/trainers, online seminars with practical examples and best practices.

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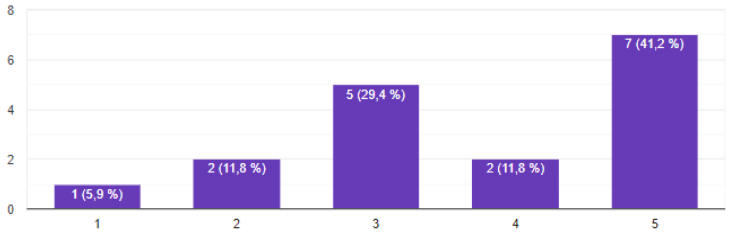
The case of Lithuania

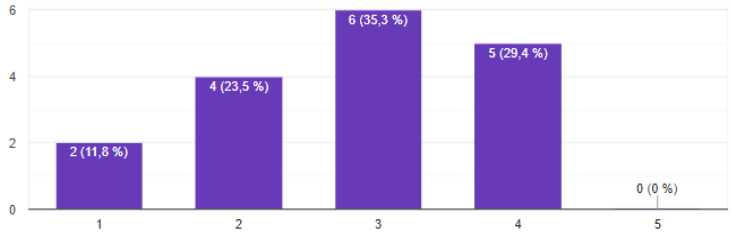
It is agreed that attention must be given in STEM education since it plays a catalyst role in the development of the country. However, the number of STEM graduates is decreasing every year. The insufficient teacher training and the provision of teaching aids and infrastructure are the main factors. In order to tackle this issue, Lithuania is planning to establish STEAM centres to gain student's interest and improve teacher's knowledge capacity and STEAM schools around the country. Also, the country established a network of STEAM schools (pre-school and general education) to encourage more students to become involved in STEAM activities. Among other non-formal and informal learning institutions, Young Computer User's School at Kaunas University of Technology, contributes to the STEM education by organizing and delivering STEM- related activities (e.g. robotics, science experiments) to students and young adults.

According to the survey, 17 responses were recorded from STEM researches (3), teachers (10) and experts (4). As shown from the results, the majority of the participants use educational innovations (e.g. toolkits, applications, digital platforms, new methodologies, programmes etc.) in STEM lessons (7= "Very much", 2= "Somewhat", 5= "Undecided", 2= "Not really", 1= "Not at all") while they see educational innovations as a big support to STEM related lessons (3= "Very much", 8= "Somewhat", 4 = "Undecided", 1= "Not really", 1= "Not at all").



Graph 5. The use of educational technologies in STEM lessons

Furthermore, it seems that respondents do not agree with the state that educational innovations can improve their monitoring and assessment of student learning in STEM lessons. Only 5 out of 17 participants stated "Somewhat" while the rest they don't know or their response is negative. In regards to, if educational innovations help to improve their teaching and learning processes in STEM related lessons, a diversity of responses emerged. Almost half of the participants support this state (4= "Very much", 4= "Somewhat") although the other half is undecided or disagree (5= "Undecided", 3= "Not really", 1= "Not at all").



Graph 6. The use of educational technologies for monitoring and assessing student's learning

In regards to the learning resources/material they would like to use, but do not have at their disposal, online simulations (15) and Augmented reality tools recorded the most responses (15). Robots

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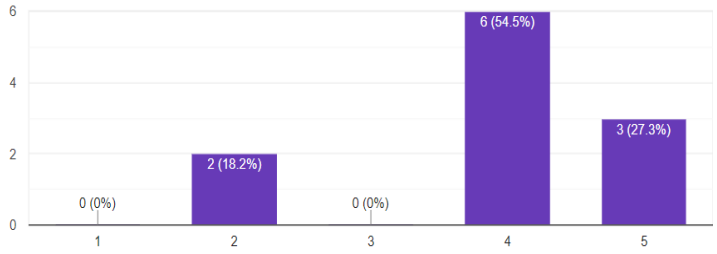
follow with 13 responses and resources for personalized learning with 10 responses. As a further support, participants mentioned that they need a STEM platform, training courses on STEM topics and how to use digital tools in such lessons, learning resources and modernized equipment.

The case of Cyprus

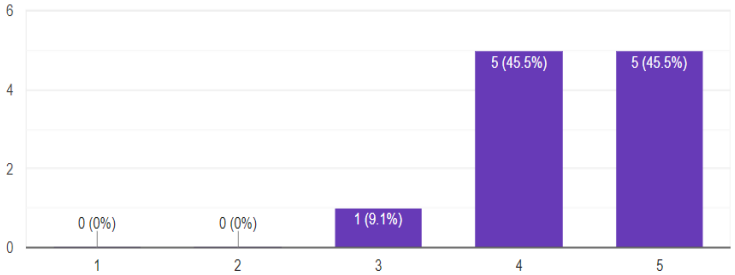
Cyprus has one of the lowest proportions of science, technology, engineering and mathematics (STEM) graduates in the EU. The Ministry of education in Cyprus shared actions to implement the "STEM schools" programme in primary and secondary education (2019-2021). Also, STEM education is integrated in the "Design and Technology" from early age until the late school years. In an effort to promote STEM education, private and public schools are actively engaging in STEM-related projects and conferences (Science on Stage). CARDET as a local organization is involved in a number of STEM projects (Girls into Global Stem (GIGS), "The Steamers 2019") and other local organisations and educational centres offer various afternoon STEM classes and activities.

According to the survey, 11 responses were recorded from teachers and researchers and about half of them stated that they teach STEM lessons at the moment. The results show that the vast majority of the participants use educational innovations (e.g. toolkits, applications, digital platforms, new methodologies, programmes etc.) in STEM lessons (6= "Somewhat", 3= "Very much", 2= "Not really") while they also believe that educational innovations can support STEM-related lessons.



Graph 7. The use of educational technologies in STEM lessons

Further, nine out of eleven participants believe that educational innovations help them very much improve their monitoring and assessment of student's learning in STEM lessons and they are capable of improving the teaching process (6="Very much", 5= "Somewhat").



Graph 8. The use of educational technologies for monitoring and assessing student's learning

In regard to the learning resources/material they would like to use, but do not have at their disposal, the most responses were recorded on the Augmented reality/Virtual reality tools (10), the experiential labs and resources published by private companies operating in STEM fields (8) and the Web-based or computer-based simulations (7). Resources for special needs learners and personalized learning concentrated a number of responses as well. Lastly, as a further support, participants mentioned that they need more STEM online courses/seminars and training how to use and integrate educational

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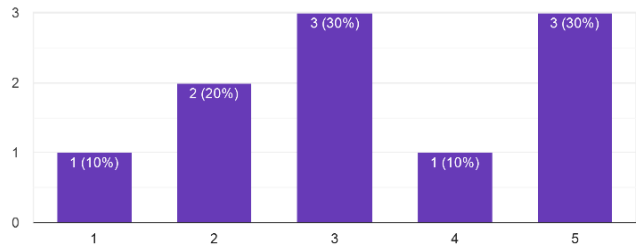
technologies in teaching practice and a well-structured STEM curriculum/Framework with material and guidelines.

The case of Greece

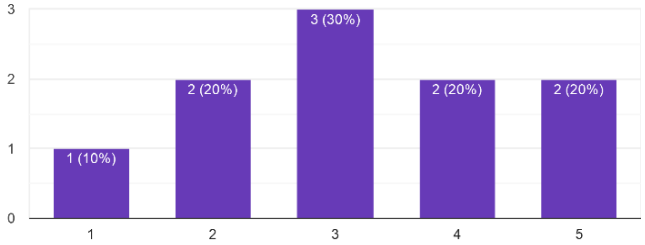
In the primary and secondary education system, STEM- related courses are part of the curriculum in all levels (e.g. Mathematic, Physics, and Biology etc.). The Scientific Unit of Natural Sciences, Technology and Mathematics of the Institute of Educational Policy, has not yet implemented STEAM activities due to lack of funding but considering the low share of digital skills among students, the country introduced the "Skill Laboratories" programme at all levels (2020-2021) including STEM/STEAM, robotics, youth entrepreneurship and creativity & innovation actions. In non-formal education, private centres (Centres for Creational Activities) offer paid STEM programmes. Institutions also promote STEM initiatives and robotics activities (FORTH -Foundation Of Research and Technology – Hellas, CISCO DT&S and WHO Hellas). Aiming to increase educators STEM knowledge capacity, education for STEM trainers is offered both by the formal and the non-formal educational sector.

The survey was completed by primary and secondary education teachers, STEM centre educators, educational policy makers, HEI professors, 10 participants in total. A great number of participants stated that they use educational innovations (e.g. toolkits, applications, digital platforms, new methodologies, programs etc.) in STEM-related lessons (3= "Very much", 1= "Somewhat", 3= "Undecided") while the majority support the state that educational innovations can support STEM lessons (3 "Very much", 4= "Somewhat", 2= "Undecided", 1= "Not at all").



Graph 9. The use of educational technologies in STEM lessons

Furthermore, half of the participants believe that educational innovations help them improve their monitoring and assessment of student learning in STEM lessons whereas the other half is not sure or disagree. However, the majority of the participants support the state that educational innovations help them improve their teaching and learning processes in STEM lessons (4= "Very much", 3= "Somewhat").



Graph 10. The use of educational technologies for monitoring and assessing student's learning

In regard to the learning resources/material they would like to use, but do not have at their disposal, Sensors, data loggers (6) Experimental Lab (6), VR/AR tools (5) and Robots (5) concentrated a number of

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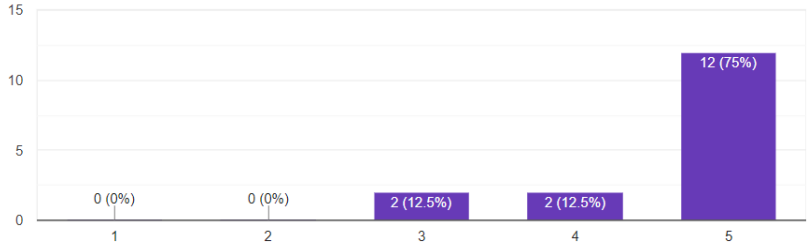
responses. As a further support, participants mentioned a structured STEM curriculum, the need of infrastructure, access to material/resources and training courses.

The case of Portugal

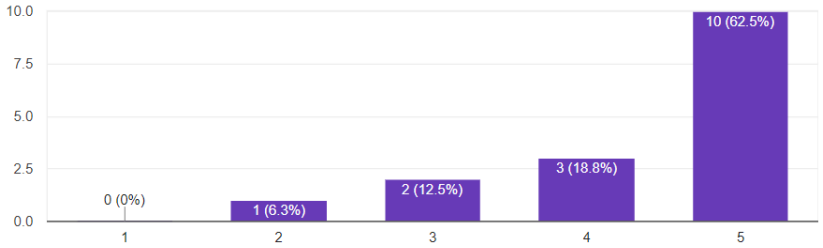
At a national level, students face difficulties in STEM related subjects, fact that affect their future career path and therefore the number of STEM professionals. The underrepresentation of women in STEM-related fields is also a matter of concern. Acknowledging the importance of developing STEM competences, Portugal is aligning towards the development of students' and teachers' STEM competences, encouraging more students to pursue a STEM career. Among other STEM initiatives, through the "Virtual School" programme, an e-learning platform was developed to support educators in preparing interactive lessons and STEM workshops for students. Further, STEM experiential workshops were delivered to students in the context of the "STEM - IBM Portugal" project on electricity, lightning, and magnets.

According to the survey, 16 responses were recorded from STEM teachers, specialists and experts. The results indicate that the vast majority of the participants use educational innovations (e.g. toolkits, applications, digital platforms, new methodologies, programmes etc.) in STEM lessons (12= Very "much", 2= "Somewhat", 2= "Undecided") while they also believe that educational innovations can support STEM-related lessons (14= "Very much", 2= "Somewhat").



Graph 11. The use of educational technologies in STEM lessons

Furthermore, ten out of sixteen participants believe that educational innovations help them very much improve their monitoring and assessment of student's learning in STEM lessons and they are capable of improving the teaching process (13="Very much", 2= "Somewhat", 1="Undecided").



Graph 12. The use of educational technologies for monitoring and assessing student's learning

In regards to the learning resources/material they would like to use, but do not have at their disposal, STEM software (12) and online simulations (11) recorded most of the responses. A great number of participants (8) mentioned experimental laboratory and augmented reality/virtual reality tools. As a further support, participants mentioned that there is a need for STEM training programmes, resources/material and financial support (e.g. software licenses).

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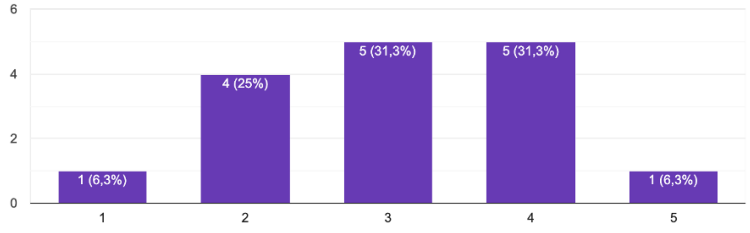
The case of Italy

According to the OECD indicators (2018), Italy's STEM graduates are among the lowest share in the EU countries whereas the employment rate of people graduated in STEM disciplines is close to OECD countries' average especially in ICT, Engineering, manufacturing and construction sector. Although women participation in the STEM field has increased, the gender gap is still significant with women prefer following non-STEM disciplines (e.g. human and social sciences). Cultural aspects and preferences seem to also affect a student's decision in following a STEM career. As per STEM practices implemented in Italy, a Course on Educational Robotics was initiated back in 2015. In particular, a number of workshops were offered to students aged between 10-14 years old utilizing the robotic kit LEGO® MINDSTORM EV3 to build smart robots. Due to its success, the LEGO Education Innovation Studio in Settimo Torinese (TO) offers the educational programme every year to children and young people aiming to enhance their problem solving and collaborative skills. Short-term STEM initiatives are also taken to narrow the gender gap such as the BYE project (Build Your Experience). It was a training programme related to coding techniques and immersive tools consisted of experiencing workshops on storytelling for female students between 6 and 16 years. The project aimed at developing young girls' technical-scientific skills to build a career in the STEM field. Lastly, "STEMintheCity" is an on-going, one year online training programme which aims to tackle the gender stereotypes in regards to girls' engagement in technical and scientific research.

According to the survey, 16 responses were recorded from teachers, trainers and experts in the STEM field. The results show that less than half of the participants use educational innovations (e.g. toolkits, applications, digital platforms, new methodologies, programmes etc.) in STEM lessons (1= "Very much", 5= "Somewhat") whereas the majority stated undecided (5) and not really (4). However, a great number of participants believe that educational innovations can support STEM-related lessons.



Graph 13. The use of educational technologies in STEM lessons

Further, most of the participants stated that educational innovations help them improve their monitoring and assessment of student's learning in STEM lessons (1= "Very much", 8= "Somewhat"). However, almost an equal number are not sure or disagree (4= "Undecided", 3="Not really"). The majority is not sure whether or not educational innovations are capable of improving the teaching process.

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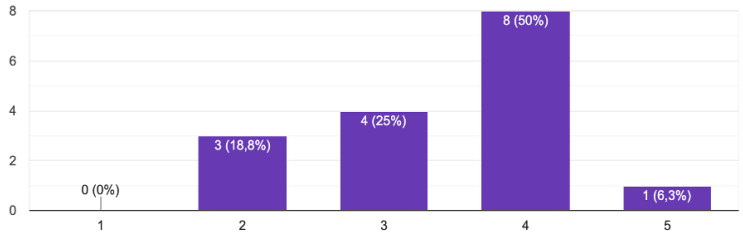

Graph 14. The use of educational technologies for monitoring and assessing student's learning

In regards to the learning resources/material they would like to use, but do not have at their disposal, the most responses were recorded on Experiential labs (10) and resources for personalized learning (7).

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Conclusion

The purpose of the STEM education research conducted in each partner country was to define the current status in STEM education and identify the needs of the educational system in order to support educators and students in the most efficient way. A total of 138 individuals from six different countries (Bulgaria, North Republic of Macedonia, Lithuania, Cyprus, Greece, Portugal, and Italy) completed the survey with experience in the STEM field (teachers, researchers, experts).

Overall, STEM education has been a matter of discussion in all partner countries. Despite the fact that STEM-related lessons such as Mathematics, Science, Design and Technology, Physics/Biology are part of the national curriculum, in the case of Cyprus and Italy STEM graduates still share the lowest percentage in the EU, while in Lithuania the percentage of the STEM graduates is decreasing every year. In the case of Portugal and Italy, students face learning difficulties particularly in STEM-related lessons since those lessons are considered very demanding and in Greece few students report above average digital skills in general. Significant gender differences are discussed in the case of Italy and Portugal where women are underrepresented in the STEM field, preferring to follow a non-STEM career. Cultural aspects are also identified in Italy where students coming from specific regions like Basilicata, Piemonte and Liguria are more likely to follow a career in STEM in contrast to students from the South of Italy.

An official and holistic STEM curriculum has not yet been implemented in any of the partner countries. Acknowledging the importance of STEM competences, various efforts are being made for the integration of STEM activities into the school curriculum. In the context of the educational reforms, Bulgaria promotes a national programme aiming to establish school STEM environments. In the case of Cyprus, STEM activities were encouraged for a period of two years in primary and secondary education (2019-2021) while a pilot school curricula is being implemented in Greece (2020-2021) that encourage the development of digital skills including STEM activities at all levels. In Lithuania, the network of STEM schools give students the opportunity to actively participate in STEAM activities and more STEM centers will be introduced to students within the year and more are coming in the next two years. As per private initiatives, Italy offers a yearly educational programme in the form of workshops on robotics, coding and STEM related topics (Library of Settimo Torinese (TO) LEIS). In North Macedonia many attempts have been made to promote STEM innovation and implement different methodological approaches.

In addition, Cyprus (Girls into Global STEAM, “The Steamers 2019”), Italy (Build Your Experience, STEMintheCity and Portugal (Project STEM - IBM Portugal) mentioned a number of short-term STEM projects conducted or will be held in their country. Also, the private sector (organizations and educational centres/institutions) seems to recognize the need of STEM by organizing and delivering STEM courses and activities to educators and students (Cyprus - ClaP3C learning and play centre, Stem Freak). In Lithuania, non-formal and informal learning institutions are very active in delivering robotic activities, science experiments to students etc. In the case of Greece, the FORTH is among the most influential institutions that promotes STEM education.

Considering participants’ feedback from the survey, a need arises for the development of a STEM curriculum/ framework that will consist of rich learning resources and material that will support personalized learning as well, good practices and lesson plan examples with guidelines for teachers and

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innovative teaching approaches to teach STEM topics. Also, they underlined the importance of access to technological tools (software, AR/VR tools, robots) to be integrated in their teaching process and enrich student's learning. Another aspect is the lack of STEM training courses that limits educator's knowledge capacity. Providing well-structured STEM courses to educators and trainers maximize the potential of organizing and implementing effective experiential STEM-related lessons.

The development of a learning environment such as a STEM education platform, will serve as a point of reference for educators, trainers, students and young people who wish to increase their STEM and digital skills. The platform will be designed based on the identified needs and suggestions provided. Lastly, to strengthen the STEM community, the platform will enable exchanging ideas and productive discussion among the users, working towards an international cooperation.

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