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STEM AND ICT EDUCATION OUTSIDE THE CLASSROOM AND HOW TO FOSTER IT FOR BETTER STUDENT'S SKILLS[13]

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Abstract: *The understanding of the world through science education is needed today more than ever after the COVID-19 crisis. Education systems have been based on transferring knowledge based on industrial society and now on post-industrial society, seldom including hands-on, student-centered methodologies. Using technology as a practical and pragmatic approach, can deliver the values of transition and of community-living-with environment to new generations that must challenge transition and lead towards the post-transition world. Together with environmental challenges, we are currently experiencing a significant industrial transformation, the fourth industrial revolution (Industry 4.0), where science along with the advancement of technology is evolving at an unprecedented speed. Education institutions are noted for being 'extremely slow in adopting the advancement of technology' in the classroom. Together with the critical perspective to information and needs for digital solutions in education. To meet the challenges of rapidly evolving new technologies, STEM formal classroom education is not enough to acquire the necessary skills. The paper studies EU and Bulgarian polices for encouraging learning outside the classroom and in particular education in STEM and ICT field. Some of good practices of outside the classroom science education across Europe are identified. Teachers from Telecommunications department at University of Ruse implemented different projects for teaching outside the formal education students from Ruse schools in the field of ICT and STEM. Some of the experimental projects for teaching outside of the classroom by professionals from Telecommunication department are presented in the paper.*

Keywords: *STEM, EU polices, ICT, educational networks, outside the classroom.*

INTRUDUCTION

The understanding of the world through science education is needed today more than ever after the COVID-19 crisis. The environmental situation is calling for new approaches for focusing on the interaction between humans and nature as ethical-political question. There is a need to "redirect our attention from essences and norms (as well as exclusions these often entail) towards processes, potentials, and possibilities…." (Radomska, 2020). Education systems have been based on transferring knowledge based on industrial society and now on post-industrial society, seldom including hands-on student-centered methodologies. Making with technology as a practical and pragmatic approach, can deliver the values of transition and of community-living-with environment to new generations that must challenge transition and lead towards the post-transition world (Hicks, 2014). Together with environmental challenges we are currently in a significant industrial transformation named the fourth industrial revolution (Industry 4.0) where science along with the advancement of technology is evolving at an unprecedented speed. Education institutions are noted for being 'extremely slow in adopting the advancement of technology' in the classroom. (Price, 2015), together with the critical perspective to information (EU, 2018). Still, formal Education can be complemented with Informal Education to cope with its shortcomings. Informal out of the school education cannot be defined in a unique, straight way, except in that it happens outside of a formal learning environment, either in presence, or online. It encompasses a huge variety of processes, activities and products, today mostly through digital learning as informal or nonformal activity, since it happens in between formal educational institutions and free-time activities online either at home or in organized settings like museums, youth centres or libraries. Digital learning is blurring the private and public boundaries and is discussed as the third space educational context

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(McDougall, 2019). STEM education has received increasing attention over the past decade with calls both for greater emphasis on these fields and for improvements in the quality of curricula and instruction (Hicks, 2014). In response, numerous new instructional materials, programs, and specialized schools are emerging. While most of these initiatives address one or more of the STEM subjects separately, there are increasing calls for emphasizing connections between and among the subjects. According to the USA National Academy of Engineering STEM Education was charged with: Identifying and characterizing existing approaches to integrated STEM education, both in formal and after-/out-of-school settings, Reviewing the evidence for the impact of integrated approaches on various student outcomes, and determining a set of priority research questions to advance understanding of integrated STEM education.

EU AND BULGARIAN INITIATIVES FOR ENCOURAGING STEM AND ICT LEARNING OUTSIDE THE CLASSROOM

Knowledge and skills related to science, technology, engineering and maths are crucial in responding to the challenges we are facing as a society. EU initiatives are driven in order to ensure smart, sustainable and inclusive economic growth and high-level jobs for young people (Bencheva, 2019). There is a strong need for more STEM and ICT graduates in Europe. In 2015 the EU STEM Coalition was established and is an EU-wide network that works to build better STEM education in Europe. It aims to increase innovation-driven growth by development and implementation of national STEM strategies in EU member states (EU STEM Coalition, 2016). Many programs have been set up to address these issues, such as the European Commission's „New Skills Agenda“ initiative, which focuses on improving the quality and relevance of STEM skills development, promoting STEM research and careers, and supporting the professional development of teachers. In some countries, they are complemented by national approaches to deal with STEM issues (European Schoolnet, 2018). In the Scientix Observatory report, based on a study, an analysis was made and recommendations for the policy-makers were done. The analysis of the STEM education practices teachers' questionnaire provides a good insight into how teachers in Europe approach STEM teaching. The study demand for actions in supporting European networks of exchange and assistance for STEM teachers to build confidence in approaching innovative teaching inside and outside the classroom.

One of the key objectives, according to the Science education policies in the EU, is that the Collaboration between formal, non-formal and informal educational providers, industry and civil society organisations should be enhanced to ensure relevant and meaningful engagement of all societal actors with science and increase uptake of science studies and science-based careers to improve employability and competitiveness (EU Policy Brief, 2016). Partnerships between teachers, students and stakeholders in STEM field can offer stimulating ways to introduce real life challenges, with their ethical and social issues and aiding problem-solving skills.

The Bulgarian national program "Building a school STEM environment" is aimed at creating new school centres - integrated set of specially created and equipped learning spaces focusing on the study and application of competencies in the STEM field. Each school centre will change the following elements: physical environment, technologies, learning content, teaching methods and management of the educational process. The program is aimed at schools with innovative practices and those with potential for development of innovations in the field of natural sciences, digital technologies, Engineering Thinking and Mathematics (MES, 2020).

The Bulgarian government has made changes to the Higher Education Act, which allows involvement of university teachers in the education of 11th and 12th grade students, as well as the use of university laboratories.

Science learning initiatives outside the classroom are crucial in educating and forming Europe's next generation of researchers and innovators (SySTEM 2020, 2020). The EU promotes, for example, the project SySTEM 2020 and it aims is to gain a better understanding of the types and kinds of programmes in operation, learn from each other and collaborate to be able to respond to challenges ahead. The achievement of these goals is set in the project through mapping initiatives that encourage learning beyond the classroom across 19 countries. Within 8 of them studies will be performed to look at how children and teenagers between the ages of 9-20 years old react to these types of environments. The Figure 1 gives definitions of the concepts of formal and non-formal learning and the differences between them.

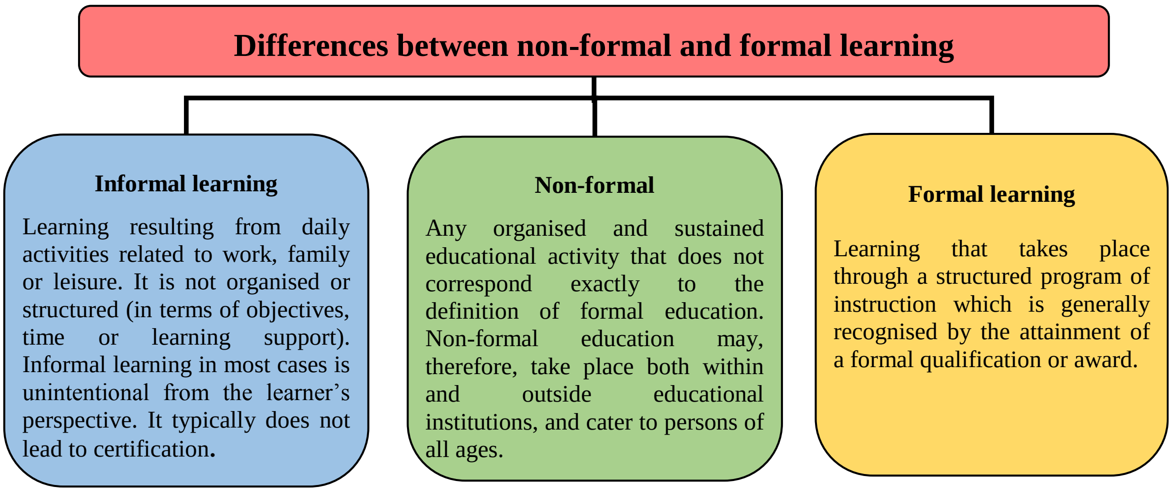

Fig. 1. Descriptions of non-formal and formal learning, (SySTEM 2020, 2020)

GOOD PRACTICES FOR STEAM LEARNING OUTSIDE THE CLASSROOM

In recent years, the introduction and creation of the so-called makerspaces, which is a very good and innovative practice. What is a makerspaces? There different descriptions makerspaces. Makerspaces are learner-centered opportunities. A makerspace is a collaborative work space inside a school, library or separate public or private facility for making, learning, exploring and sharing that uses high tech to no tech tools (MakerSpaces, 2020). These spaces are open to kids, adults, and entrepreneurs and have a variety of maker equipment including 3D printers, laser cutters, cnc machines, soldering irons and even sewing machines. These spaces are also helping to prepare those who need the critical 21st century skills in the STEM fields. They provide hands on learning, help with critical thinking skills and even boost self-confidence. Some of the skills that are learned in a makerspace pertain to electronics, 3d printing, 3D modelling, coding, robotics and even woodworking, Makerspaces are also fostering entrepreneurship and are being utilized as incubators and accelerators for business startups. These places have many verity of advantages. Some of the most important ones concerning the improvement of STEM training are:

- Providing the opportunity to innovate;
- Makerspaces are inter-disciplinary reflections of real life. They help for creating real-world applications;
- Collaborating with other students more;
- Gaining confidence in students abilities
- Help students learn to take failure in stride;
- Exposing students to new opportunities;
- Building critical thinking of the learners and problem-solving skills;
- Developing a wide range of 21st century skills. Makerspaces help to prepare students for the future;
- Makerspaces engage community and invite cross-generational learning

The Department of Telecommunications at the University of Ruse has initiated in the last 10 years various events, including seminars, trainings, exhibitions and others in order to attract students to STEM and ICT careers, as well as to assist their teachers in their professional education. One such initiative was a one-day course on „Technologies for 3D scanning, modelling and development of applications with virtual and augmented reality“. The course targeted both 11th and 12th grade students, as well as ICT teachers from secondary schools. The content of the course included information about methods for development of images, orhtophotography, photogrammetry principles, etc. The course also presents different methods for computer modelling, use of specialized software and products. The course was met with great success and was attended by more than 250 people. This shows the potential of these technologies and the interest of the students in them. The long-term cooperation between the university and the local schools was strongly improved by the course and many of the ICT teachers expressed their willingness to work with the university professors and to develop further out-of-the-classroom courses for their students. One of the goals was that the training course has to overcome learning barriers seen in the classroom. It was conducted more practically oriented. The materials were carefully selected to correspond to the interests of the participants. The delivery was not made using presentations, but instead the lecturers presented real working and programming environments and developed the materials in front of the auditory. All the participants received certificates for attendance.

The initiatives of the teachers from the Department of Telecommunications are aimed not only at the last grades of high school education, but also at younger students, as they are convinced that work to attract STEM education should begin at an early age. One such initiative is a course for „Block-based programming of drones" with 6th and 7th grade students from the largest school in the city of Ruse and the Mathematician school. The training course was focused to be delivered to 12-16 years old school students, which are unfamiliar with the programming concepts. The contents of the teaching program was discussed and agreed with the teachers form the secondary schools. The course is introductory and consists of 12 practical exercises, which are focused on the development of different programming codes for control of small-scale drones. The students receive the basic programming skills, but without the need to learn any specific programming language. This course combines the STEAM approach and the practical education for the use of drones. The methodology of the course included the integrated method for solving a practical problem in STEM training, because together with the acquisition of programming skills, students had to apply their knowledge of mathematics in a very attractive way through control of drones. The tasks related to the programming and use of various mathematical functions did not require prior training and knowledge. The courses were delivered in the presence of teachers from the two secondary schools. The certificates for completion of the courses were delivered to the students by the Principals of the Schools. The knowledge and skills that students gained in this type of non-formal learning outside the classroom complement formal learning in mathematics, information technologies and programming – both object oriented programming and block-based (Scratch) programming.

CONCLUSIONS AND RECOMENDATIONS

Thanks to the EU and national policies, based on support through various programs and projects, many training courses and tolls have been created to provide and insure learning conditions and environments for education outside the classroom. This support is directed for both learners and trainers. Out of the classroom training programs are a sought-after teaching practice, as evidenced by the examples given in this paper. These programs are accessible to a wide audience from children, young people to adults - which makes science more engaging, turning theoretical concepts into real applications and placing them in the context of the global problems we face now and in the future. However, non-formal education also has a number of challenges inherent in its unstable organization, dynamic nature and high heterogeneity. There are still no adopted standards for assessment of expected results and quantitative indicators that can be used to assess learning outcomes and validate the acquired knowledge and skills. The challenge here is that despite the achievements of many teaching programs and courses outside the classroom, there is no accreditation for the formal integration of such activities into formal education. In order to foster of non-formal learning and make it a priority for all stakeholders, it is necessary to accelerate the development of assessment methodologies and accreditation of learning outside the classroom.

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