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ABOUT THE STEM EDUCATION

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Abstract: *The STEM acronym was introduced in 2001 by scientific administrators at the U.S. National Science Foundation. STEM is an interdisciplinary and applied approach that integrates science, technology, engineering, and mathematics into a cohesive learning paradigm based on real-world applications. STEM education refers to teaching and learning in the fields of these four subjects. It typically includes educational activities across all grade levels—from pre-school to post-doctorate—in both formal (e.g., classrooms) and informal (e.g.,afterschool programs) settings.*

The paper presents theoretical background about STEM: variations, definitions, characteristics and examples. Special attention is paid to the STEM-lessons and STEM-skills. Research about how some countries used STEM in education is included.

Keywords: *STEM-Education, STEM-skills, hands-on activities.*

INTRODUCTION

In the XXI century, scientific and technological innovation has become increasingly important, given the benefits and challenges of both globalization and the economy based on knowledge. To succeed in this new information-based and high-tech society, students should develop their abilities at Science, Technology, Engineering, Mathematics - STEM at the highest levels (US National Science Foundation, 2016).

Recently, STEM abilities have been added to various kinds of art (STEAM). STEM skills are becoming an increasingly important part of today's society. Careers related to STEM are one of the fastest growing and the best paid.

The Education and Training Survey for 2017 (European Commission, pp. 19-25) includes key findings and information on policy measures and the latest reforms of the twenty-eight countries, some of which are: Austria has an extremely stable and professional oriented short-cycle higher education, including in the fields of natural sciences, technology, engineering, and mathematics. In Belgium, initiatives are being taken to solve the problem of the low number of graduates in the field of natural sciences and technologies and gender imbalances. The percentage of university graduates in Latvia is high, but providing sufficient STEM graduates for sectors requiring a high level of knowledge continues to be a challenge. In the Romanian system of school education, competency-based curricula are applied. Teacher training plans are being prepared to be able to teach the modernized curriculum.

Therefore, the European Commission has taken measures to solve the problem of the low number of graduates in the field of natural and engineering sciences, technology and mathematics.

PRESENTATION

In 2001, the NSF introduced the SMET (Science, Maths, Engineering, Technology) acronym, and later Judith Ramalie rearranged the words and formed the STEM acronym for integrating science, technology, engineering and mathematics into a new interdisciplinary subject. Another STEM version is STEAM, which includes different types of art and design.

The main reasons for introducing STEM education in the US are two: the need for sufficiently trained STEM students, teachers and practitioners; the needs of the industry by having more workers in these areas due to the aging workforce and an increasingly innovative global market. STEM is divided into two categories: STEM training / education and STEM workforce.

The STEM-focused educational program has been expanded in many non-US countries, such as Australia, China, France, South Korea, Taiwan, the United Kingdom and Western Europe.

There are different definitions of STEM education, for example:

- an interdisciplinary approach to education by integrating the four disciplines into a coherent paradigm of teaching and learning. Academic concepts are combined with real-world lessons where students apply science, technology, engineering, and mathematics to connect school, community and work, and develop STEM literacy and competitiveness in the new economy (Morrison, 2008 ; Tsupros 2008, 2009);
- an international educational paradigm (Chemekov, 2015, p.60);
- innovative methodology where real knowledge is solved by applying scientific knowledge (Brown, Brown, Reardon & Merrill, 2011; Marick, 2016; Gavito, 2017).
- a method that promotes interdisciplinary and cross-functional knowledge and helps students develop their thinking as a coherent and complex process (Tomov, 2018, p. 7).

STEM integrates the four disciplines into a single model of education on the basis of real-world examples and applications, and its goals are:

- effective application of the knowledge in each of the disciplines;
- developing the curiosity of children, pupils and students, their creative potential, the ability to observe, to make hypotheses and conclusions;
- developing students' skills to find solutions, implement improvements and innovations;
- forming and developing skills for observation, exploration, experimentation and explanation, not simply memorizing and reproducing information.

The main activities are:

1) **Science:** observation, comparison, description, experiment, forecasting, asking questions, looking for reasons, creating explanations and drawing conclusions, presenting results.

2) **Technology:** identifying a problem, exploring possible solutions to achieve something, using tools (from a screwdriver to software applications), looking for improvements, inventing.

3) **Engineering:** solving real problems, using different materials for construction, design, planning.

4) **Mathematics:** comparing, measuring, counting, finfing models, study of geometric shapes, etc.

Therefore, STEM encourages young people in their research, which supports the development of a knowledge-based economy and technology.

The STEM lesson focuses on finding a solution to a real problem and providing an understanding of the relationship with the real world by students. Project-based learning is often applied. The teacher should take the role of a facilitator in the classroom or in the lab. Therefore, it is necessary to pay attention to and reduce the barriers to the successful implementation of STEM education, some of which are: the loss of interest in STEM disciplines by students; the shortage of STEM qualified teachers, the lack of investment in professional development of teachers and research in cooperation with STEM.

EU Skills Panorama (2014, p. 1) states that the understanding and scope of STEM skills varies considerably across countries. The development of STEM skills is an extremely important policy area. STEM-related industries are considered key to continued innovation, the development of knowledge-based economies and the competitiveness of Europe in the context of rapid globalization. It is necessary to further develop science and innovation in Europe, using the strengths and talents of STEM specialists to improve the quality and impact of STEM activities. EU Skills Panorama also states that STEM skills include capabilities for: generating, understanding and analyzing empirical data; understanding of scientific and mathematical principles; application of theoretical knowledge, systematic and critical evaluation to solve complex practical problems; communicating scientific news to stakeholders; intuitiveness, logical thinking and practical intelligence (2014, p. 1). The main STEM topics usually include mathematics, chemistry, informatics, biology, physics, architecture, electrical engineering, electronics, communications, mechanics, construction, chemical engineering, and more.

Good practices

STEM helps kids learn more about programming, coding and logic. Mentors use a variety of educational games and interactive materials, intelligent toys as well as diverse learning approaches to inspire children and raise their interest in science, technology, engineering, and mathematics.

The specialty *Robotics for Children* is a mandatory component of STEM education. For this purpose, LEGO constructors have been developed to provide students with the ability to build, program and test their solutions with real robots. They allow children to work with sensors, motors, modules and other components as well as change and set commands for the robotic mechanisms they have created. Even in the primary school, the help of these constructors, they create something of their own and develop the imagination by developing, programming and controlling robotized mechanisms. Some kits and models even allow for planning, testing, and modifying the behavior of robots. This is a promising direction, so we need to invest in such interactive learning (Teacher.BG, 2017).

On the occasion of the *European Programming Week*, a visit of pre-school children at the Technical University of Gabrovo was organized in October 2018, during which industrial robots of the highest class were shown, which are the future of the industry in the world scale. Mobile phone robots (GSM) and models of children's cars with built-in sensors and alarm systems have been demonstrated (Figure 1, Figure 2).

Fig. 1

Fig. 2

Another alternative is the scientific or technical constructors, which are very entertaining for both children and adults. Through them the children successfully develop their creative potential, their ability to observe, to raise hypotheses, to draw conclusions, to find solutions, to make improvements and innovations. STEM constructors for children are fascinating and interactive, through which various scientific and engineering experiments are carried out to help them find solutions independently.

The consortium of the STEM4youth project, coordinated by the Warsaw Technological University (Poland), consists of 10 organizations from 6 European countries. The project (May 2016 - October 2018) aims to develop a multidisciplinary STEM course as well as guidelines for teachers for formal, informal, controlled and uncontrolled training. The main tools and methods of training in the project are: *educational games; multimedia* (audio, video, graphics, text, animation, etc.); *learning by doing* - focuses on solving real-world challenges, applying old knowledge to solve new problems, and is oriented towards interdisciplinary and self-study; *learning by experiment* actively involves pupils in the performance, forecast, monitoring, and recording of results (Brzozowy et al., 2017, pp. 5-6). Student education materials have been developed. An example of this is a puzzle by which with minimal incorrect attempts, vectors have to be calculated of the vector pairs and linked to the coordinates of the newly obtained vector. Every correct answer reveals part of a quote by the famous German mathematician Georg Kantor (Figure 3, Figure 4).

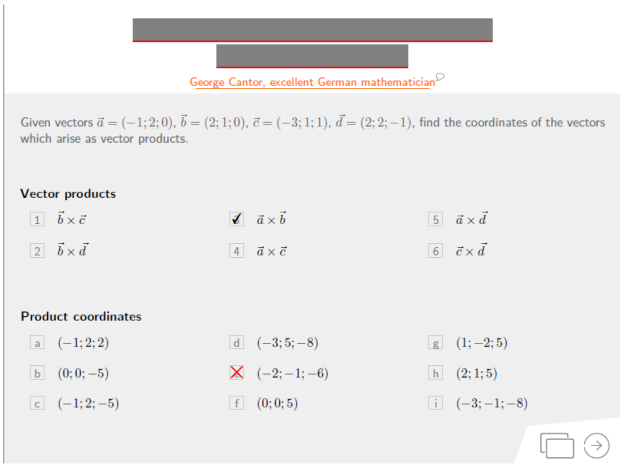

Fig. 3

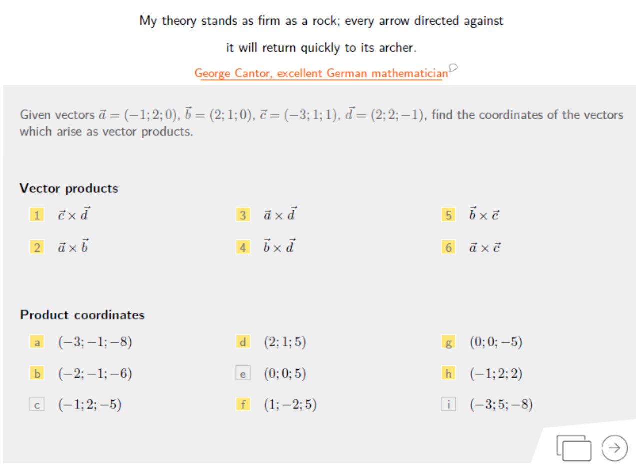

Fig. 4

The Scientix project (http://www.scientix.eu) was created as an initiative of the European Commission in 2009, and is managed by the European University Network (EUN). His third phase (2016-2019), funded by the European Union's Horizon 2020 program, is currently underway. Its primary objective is to promote and support pan-European cooperation between teachers, researchers, policy makers and other professionals involved in STEM education. Scientix's largest contribution is the creation of a pan-European network for the exchange of ideas, practices and experiences that are essential to the modern development of mathematics and science education. The Scientix resource repository has a huge amount of educational materials and shared good practices related to mathematics and science education. The repository ensures access to resources even when a project is over and if the server has stopped supporting its site. Last but not least, these materials fall into a common category along with the thematically similar ones and thus complement each other. Site searches can be done in several ways, such as: a keyword or a word combination; area, with choices ranging from over 30 educational areas - from art to technology; age group (by setting a minimum and maximum age); by type of resource: video, educational game, text, simulation and others (Ivanova, Sendova, Chehlarova, 2015, p. 13).

The professional fields that are funded with priority in state universities include STEM, particularly ICT and mathematics. Taking into account the focus of the reform on STEM and the results of Bulgaria within PISA, improving the quality of secondary education and further strengthening career guidance are important aspects (Education and Training Survey, EC, 2017, p.10). In respect to the increased need for people with knowledge and skills related to science, technology, engineering and mathematics, the Ministry of Education and Science is in the process of developing a Bulgarian STEM platform. In May 2018, a Council on Science, Technology, Engineering and Mathematics (Bulgarian STEM Coalition) was set up to promote, coordinate and develop STEM education in Bulgaria.

CONCLUSION

The need to improve the quality and adequacy of scientific education and STEM among young European citizens is recognized at both European and national level. Some countries still have to seek improvements in this area. Europe is fighting against the current situation of high unemployment among young people. This underlines the urgent need to address the importance of STEM at all levels - world, European and national.

The most important issues for ensuring the labor market are related to: improving teaching and learning in the field of science; raising student interest towards STEM; looking for long-term projects and programs to promote STEM education; raising the general level of public awareness of the seriousness and relevance of science education and STEM; developing teacher programs; promoting the need for innovative tools and effective teaching methods in schools.

Technology and science are developing lightning fast, STEM is the future, and children's development depends on being well utilized!

REFERENCES

Brzozowy et al. (2017). Making STEM education attractive for young people by presenting key scientific challenges and their impact on our life and career perspectives, 11th International Technology, Education and Development Conference, Valencia, Spain. 6-8 March, 2017.

Carter, Vinson R. (2013). Defining Characteristics of an Integrated STEM Curriculum in K-12 Education" Theses and Dissertations. URL: http://scholarworks.uark.edu/etd/819

Elizabeth A. Ring et al. (2017). The Evolution of Teacher Conceptions of STEM Education Throughout an Intensive Professional Development Experience. Journal of Science Teacher Education. URL: https://www.sciencedaily.com/releases/2017/10/171004095119.htm (Accessed on 21.09.2018).

European Commission. (2017). Education and Training Monitor Country analysis, 315 p.

European Commission. (2017). Commission staff working document accompanying the document proposal for a Council recommendation on Key Competences for LifeLong Learning, Brussels, 17.1.2018, 104 p.

Maryland STEM: Innovation Today to Meet Tomorrow's Global Challenges. URL: http://mdk12.msde.maryland.gov/instruction/ccr_conferences/resources/E114/ES%20STEM%20101%20Participants%20Resources_1of2.v1.doc.pdf (Accessed on 21.09.2018).

Parker, C.E., Pillai, S., Roschelle, J. (2016). Next Generation STEM Learning for All: A report from the NSF supported forum. Waltham, MA: Education Development Center.

Stohlmann, M.; Moore, T.; and Roehrig, G. (2012). Considerations for Teaching Integrated STEM Education," Journal of Pre-College Engineering Education Research (J-PEER): Vol. 2: Iss. 1, Article 4. URL: https://doi.org/10.5703/1288284314653 (Accessed on 20.09.2018).

Ivanova, K., T. Chehlarova, E. Sednova. (2018). Matematikata v sveta okolo men – edno sabitie v ramkite na STEM DISCOVERY WEEK 2018, XI Natsionalna konferentsiya Obrazovanieto I izsledvaniyata v informacionnoto obshtestvo, pp.152-161 (***Оригинално заглавие***: *Красимира Иванова, Тони Чехларова, Евгения Сендова 2018 "МАТЕМАТИКАТА В СВЕТА ОКОЛО МЕН" – ЕДНО СЪБИТИЕ В РАМКИТЕ НА "STEM DISCOVERY WEEK 2018" XI Национална конференция „Образованието и изследванията в информационното общество",* с.152-161).

Ministerstvo na obrazovanieto i naukata, Balgaria se prisaedini kam Evropeyskata STEM koalitsiya (***Оригинално заглавие:*** *Министерство на образованието и науката, България се присъедини към европейската STEM коалиция*) https://mon.bg/bg/news/2991(Accessed on 01.10.2018).