

DEVELOPMENT OF STEM COMPETENCES THROUGH COOPERATION BETWEEN SECONDARY AND TERTIARY EDUCATION LEVEL; EVIDENCES FROM BROD-POSAVINA COUNTY

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<https://doi.org/10.31410/itema.2018.923>

Abstract: *European Union today represents technologically advanced, yet dependant society, facing many social and economic challenges. It is therefore essential for the citizens of EU to develop, from the earliest age, transversal and basic skills in the STEM field (STEM-Science, Technology, Engineering, Mathematics), also recognized in the European Commission's paper on education. Although, knowledge and competencies in STEM field are increasingly important component of the set of skills needed in today's economy of knowledge, still, in the most of the EU countries, interest for the STEM field is decreasing. As a direct result, there is also decreased interest of students for STEM oriented studies and carrier in the STEM field, which represents threat to the competitiveness of the EU economy on the global scene. It is considered that, until 2020. there will be lack of more than 800.000 technological experts, and even on the lower positions, increased level of STEM competences, will be essential. Therefore, this issue is extremely important for the future of EU.*

Current educational plans and programmes are often outdated, focused on reproduction instead on learning outcomes and students. Practice shows that educational programmes and teaching methods, as well as technical conditions, are not following technological development or modern society needs. Teachers are often oriented to the transmission of large quantity of information without concrete application, innovation, creativity or freedom of expression, which leads to the lack of development of social skills and expression of student's own attitudes. PISA results show that Croatian's 15-year old are falling significantly behind their peers in the world, clearly proving negative impact of such a practice to the students' results.

Project „STEM geniuses“, funded by European Social Fund, is developed as a tool in the process of finding the solution to the detected problems. Starting point was encouragement to the stronger cooperation of high-school institutions with Faculty, Scientific institute and Scientific-technological Park, introduction to the best EU practice and education of teachers in the field of modern, student-oriented educational methods. Capacity building of teachers of both Gymnasiums in the field of application of didactical-methodical systems allowed more creativity and autonomy in the selection of learning content and methods with adequate equipment, as well as clearly defined standards and evaluation criteria focused on learning outcomes. In addition, students, parents and the public have raised awareness of the importance of STEM competences for future competitiveness in the labor market.

As a precondition for implementation of new learning contents, innovative curricula were developed focused on competences in the field of STEM and ICT and, in order to assure its successful implementation in the educational system of Gymnasiums, teachers increased competencies while the facilities were equipped with modern equipment. Students, parents and general public were informed about significance of STEM competencies and entrepreneurship

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was introduced as an innovative element and one of the basic components necessary for successful life and learning in the modern society.

Keywords: *STEM competencies, Secondary education, Tertiary education, Brod-Posavina County*

1. INTRODUCTION

Latest economy crisis in year 2008 revealed numerous structural flaws of European economy and, as an imperative, set out the need for strategy that will enable European Union to create smart, sustainable and inclusive economy with high rates of employment, productivity and social cohesion. The most important EU strategic document, Europe 2020, brings the vision of social market economy for 21st century, based on 3 priorities:

- 1) Smart growth: developing an economy based on knowledge and innovation (promoting knowledge, innovation, education and a digital society)
- 2) Sustainable growth: promoting a low carbon, resource efficient and competitive economy (making our production more resource efficient while increasing competitiveness)
- 3) Growth for all: stimulating an economy with high employment and social and territorial cohesion (increasing labour force participation, improving skills and reinforcing the fight against poverty) [1]

In order to achieve smart, sustainable and inclusive growth on the EU level, member states need to act in synergy on their national levels. It can be obtained through implementation of priorities and objectives from EU 2020 into national strategies and objectives.

STEM related competences today represent the most important segment of skills in economy of knowledge. Nevertheless, in most of EU countries interest and achievements in STEM field are decreasing, which puts great risk on realization of EU 2020 objectives and priorities. Having in mind the fact that in world economies, which represent main competitors to the EU economy, there is a trend of growing number of STEM related experts, it is clear why there is concern regarding increase in a gap between demand and supply of qualified STEM related experts in European Union.

In order to deliver priorities and objectives set out in EU 2020 Strategy, European Commission presented initiatives within each priority topic and elaborated activities on EU level and on the level of individual member states. To that aim, initiative „Innovation Union“ foresees that all member states will need to ensure a sufficient supply of science, math and engineering graduates and to orient school curricula on creativity, innovation, and entrepreneurship, i.e. to STEM field.

One of the instruments for implementation of aforementioned initiatives are European Funds, especially European Social Fund which aims, among other things, to enhance educational and lifelong learning sectors as well as to improve human resources and create preconditions for stronger and more competitive economy.

This article presents cooperation of secondary and tertiary education level during the implementation of project „STEM geniuses“, funded by European Social Fund. Project was implemented during 2015 and 2016 by Gymnasium Matija Mesić in Slavonski Brod in

partnership with Gymnasium Nova Gradiška and Mechanical Engineering Faculty in Slavonski Brod.

2. ANALYSIS OF EDUCATION SYSTEM IN CROATIA WITH EMPHASIS ON STEM FIELDS

When comparing Croatian education system with education systems in Organization for Economic Cooperation and Development (OECD) member states whose students achieve highest results on international competitions of knowledge and skills, we can say that Croatian system is highly centralized and traditional with rigid structure of subjects and time schedules. Gymnasiums are no exception to that, with organizational structure and curricula that have been unaltered since the mid 1990's. Existing learning plans and programmes are often obsolete and focused on the reproduction of learning contest instead of learning outcomes, i.e. student himself. In the classroom it has also been evident for a long time that teaching methods in existing learning programmes are outdated and do not follow modern trends in technology or needs of modern society.

Teacher's work is mostly focused on transfer of large quantity of information which does not allow teachers the freedom to apply their knowledge, creativity and innovation consequence of which is lack of development of social skills, expression of statements and opinions of students. Such practice reflects largely to the students' success, as show the results of PISA research according to which Croatian 15 years old significantly fall behind their peers in international context. [2] Similar situation occurs with state final exam for high-school graduates where gymnasium students choose basic exam level, although, they are expected to take higher level in order to be able to enroll to universities of their choice. As for younger students, results in the field of mathematics and natural science also reveal generally low results comparing to international averages. In the field of higher education, during the academic year 2011/2012, out of total number of enrolled students (49.016) only 19.794 have enrolled in STEM related studies. During the next academic year, only 10.034 students fulfilled the criteria for advancing to the second year, which means that 41% of students did not passed all exams related to the key STEM and ICT fields during the previous year. [3]

3. SITUATION ANALYSIS IN BROD-POSAVINA COUNTY

In school year 2012/2013, only 30% of students in Gymnasium Matija Mesić Slavonski Brod have enrolled in one of STEM studies [4], out of which most have enrolled in Mechanical Engineering Faculty in Slavonski Brod. Also, monitoring of success of former students of Gymnasium on faculty also shows problems with progressing to the next academic year. Some of the reasons, i.e. **SPECIFIC PROBLEMS** are **outdated learning programmes** oriented on context and not on student; **lack of laboratories** equipped with modern high-tech equipment; **teachers lacking permanent vocational training** for application of modern didactic and methodical systems and for creation of standards/criterion for validation of learning outcomes, but also **lack of systematic promotion of STEM competencies and sensibilisation** of students, parents and public regarding **competitive advantages** of STEM experts on the labour market already, but especially in the future. This is specifically important for Brod-Posavina County which is one of the 4 counties with **highest unemployment rates** in Republic of Croatia (**29,1%** 12/2014). [5]

4. EU FUNDS IN SERVICE OF STEM KNOWLEDGE AND COMPETENCES

European Social Fund (ESF) is one of the main instruments of European Union for implementation of measures for enhancement of human capital and participation on labour market. It is achieved through the reform of education system aimed at increase of employability of participants in the labour market, relevance and quality of initial vocational education and higher education, as well as at permanent improvement of workers' competencies in order to create innovative knowledge-based economy. Furthermore, ESF is oriented toward implementation of measures related to the networking of higher education institutions, scientific organizations and companies with goal to develop human capital in science and research.

Call for proposals „Promotion of quality and improvement of education system on high-school level“ was implemented within Priority 3 Enhancing of human capital in education, research and development. General objective of the Call was „*implementation of education system that allows acquisition of competences, knowledge and attitudes needed for successful living and learning in the modern society*“. [6]

Specific objective of the Call was „*establishing programme, personnel and material preconditions in gymnasiums in order to allow students to gain additional competencies in the field of mathematics, natural science and information-communication technologies*“. Target groups of the Call were students and teachers in gymnasium programmes, principals and expert assistants in gymnasiums.

5. PROJECT „STEM GENIUSES“ – FRAMEWORK FOR COOPERATION BETWEEN SECONDARY AND TERTIARY EDUCATION LEVEL

Project „STEM geniuses“ established cooperation between secondary and tertiary education sector in order to enhance STEM competencies of students and to foster them to the STEM related career. Partners in project were representatives of secondary sector (Gymnasium Matija Mesić Slavonski Brod and Gymnasium Nova Gradiška) and representatives of tertiary sector (Mechanical Engineering Faculty in Slavonski Brod).

Project set out general and specific objectives and their relevance in relation to the Call and needs of the target area as well as their conformity to the strategic documents of higher level. Duration of the project was 12 months and following activities were conducted:

1. Enhancing teachers' competencies for preparation and implementation of curricula
2. Development of facultative curricula in the STEM and ICT fields
3. Improvement of material capacities for implementation of newly developed curricula
4. Dissemination of newly developed curricula and promotion of STEM competencies
5. Promotion and visibility
6. Project management and administration

Target groups within this project were teachers (61) and students (55) in both gymnasiums, principals (2) and professors of Mechanical Engineering Faculty in Slavonski Brod (4). [7]

Students of Gymnasium Matija Mesić Slavonski Brod and Gymnasium Nova Gradiška less likely choose STEM studies for 2 reasons – one reason is because they are not informed of possibilities and advantages of STEM career, and second reason is because they don't have

sufficient competencies in STEM fields. Furthermore, those students which enroll to the STEM faculties, don't achieve expected results because their STEM competencies are not aligned with higher education requirements, which makes difficult for them to progress to higher academic year and to obtain diploma which would increase their competitiveness on the labour market. Reason for that lies in outdated gymnasium curricula and in the lack of modern equipment in schools, that would allow conduction of various experiments that serve to stimulate independent thinking and conclusion. Competitiveness of gymnasium students on labour market is especially low because their high-school certificate is not valid until they pass final state exam. Additional specialization in STEM, ICT field and work on modern equipment and technology motivates students to continue with their education in STEM field and support their progress to the next academic year, which increases their employability and competitiveness on the labour market.

Teachers in the STEM field lack education for application and usage of new technologies and innovative methods of teaching because school does not provide opportunity for additional improvement of their knowledge and competences that later can be transferred to their students. Through the project „STEM geniuses“ they were given the chance to enhance general and pedagogical capacities and to contribute to attractiveness of not only STEM and ICT field, but also attractiveness of gymnasium programme and their institutions.

5.1. RELEVANCE OF THE PROJECT TO THE SPECIFIC SECTORS IN TARGET GEOGRAPHICAL AREA

Implementation of project „STEM geniuses“ tackles growing problems in several areas: Knowledge based economy in which there is a growing need for STEM related experts which can answer the challenges of fast changes and need to follow world's trends in technology. In larger region of Brod-Posavina County there is a strong tradition of industrial production which still exist, despite of economy crisis;

Gymnasium education programme needs changes through innovation of teaching plans and programmes, training of teachers, introduction of innovative methods and processes in teaching programme. Poor economic situation in Brod-Posavina County is followed by extremely low rate of investment in material and technical capacities of educational institutions which results in lack of equipment in schools, especially equipment needed to follow-up latest scientific and technological achievements, and slow progress of education quality level. Consequence of this is decrease of students' competitiveness for further education as well as for labour market;

Progression to the higher education is essential for gymnasium students, because their competitiveness on the labour market is extremely low if they don't continue with their education. Improvement of progression is achieved through the cooperation with Mechanical Engineering Faculty in Slavonski Brod (MEF) during the preparation of STEM curricula; Youth represent especially vulnerable category with exceptional risk of long-lasting unemployment. Project „STEM geniuses“ contributed to the increase of employability of young people in Brod-Posavina County which is very high on the list of youth unemployment.

5.2. COMPLIANCE WITH STRATEGIC DOCUMENT

In order to achieve synergy with other initiatives and projects aimed at enhancement of education sector, project „STEM geniuses“ is complied with higher strategic documents such as: Operational Programme Human Resources Development 2007-2013 [8]; Strategic plan of

Ministry of Science and Education 2014-2016 [9]; Strategy of Education, Science and Technology [10]; Law on education in elementary and secondary schools [11]; Development Strategy of Brod-Posavina County 2011-2013 [12]; Human Resources Development Strategy of Brod-Posavina County 2011-2013 [13]; Strategic framework for European cooperation in education and training [14]; EU 2020 - Education [15]

5.3. RESULTS OF PROJECT „STEM GENIUSES“

In order to establish programme, personnel and material preconditions that will allow students to gain additional competences in the STEM field, 5 facultative STEM related curricula were prepared and material and human capacities were improved in both gymnasiums. E-learning portal and digital content, as well as education of teachers for usage of digital content in implementation of curricula supported improvement of ICT competences and implementation of Open Educational Resource (OER). All that contributes to the enhancement of quality of education process and improve access to the education to all students under the same conditions as well as free access to education material, their multiple usage, exchange and distribution.

Cooperation with faculty, scientific institute and scientific-technological park, introduction to the best EU practice and education of teachers about newest student-focused education methods contributed to the enhancement of teachers' capacities in both gymnasiums for application of didactical-methodical systems that allows more creativity and autonomy of teachers in selection of content, methods and form of work with adequate equipment, as well as precise examination standards and criteria for learning outcomes. Besides, students, parents and public are sensibilised for the importance of STEM competences in terms of competitiveness on the labour market. Project introduced entrepreneurship as innovative element and one of the basic competences for successful living and learning in modern society. [7]

6. CONCLUSION

Despite different national practices in EU member states, what they have in common is effort to increase number of students in STEM related studies. To that end, numerous initiatives have been started in order to promote positive image of science, to raise awareness of importance of science for the economy, to increase interest of students for science and to improve gender balance in the STEM field. Change in the attitude of young people towards science is long-term and demanding project, which real effects will be seen in the future.

Brod-Posavina County analyzed the situation in the education field and detected problems and needs related to the lack of STEM experts, and decided to make use of EU funds in order to contribute to the solution of detected problems.

Implementation of project „STEM geniuses“ additionally enhanced cooperation between secondary and tertiary education level which resulted in better preparedness of students for faculty programmes and better progression to the next academic year. Additional value was accomplished by connecting the primary and secondary education level through promotion of STEM occupations in primary schools and motivation of primary school students to enroll in gymnasium programmes.

Having in mind that the project's effects are expected to be seen over a longer period of time, it is necessary to monitor enrolment rate to the STEM faculty programmes as well as progression to the next academic year. Depending on the findings, it is necessary to make additional efforts

in promotion of science, equipping schools and faculties with modern equipment and enhancing teachers' and professors' capacities for application and usage of modern teaching methods.

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