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**A NEW VISION ABOUT THE STIMULATION OF STEM
EDUCATION IN ROMANIA**

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Abstract

This paper aims to investigate the importance of STEM (science, technology, engineering and mathematics) education for the future generations of the builders of forthcoming world. The first part of the paper emphasises the critical situation regarding the interest in STEM education by briefly exploring its current condition across the European Union member states. This part shows that the interest in choosing STEM education as a foundation for future career path is confined in all aspects: the number of enrolments, the number of graduates in science and the percentage of tertiary education graduates in STEM from the total number of tertiary graduates. The second part of the paper assesses the possibilities to stimulate the students to select a career path based on STEM and is mainly focused on Romania's example. This part shows that a new vision is needed for the support of STEM education, from primary to tertiary education. This vision includes the implication of multiple stakeholders, from teachers to industry, from policy makers to local communities. This research has as main results the original identification of barriers, main actions to overcome the barriers and key priorities aimed to stimulate the STEM education at national level. The findings of this paper may be used as best practices to be pursued by policy makers, industry facilitators, schools and universities in order cope with a more competitive world, where the supply and demand of STEM qualified professionals is to be better matched.

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1. Introduction

STEM (science, technology, engineering and mathematics) education is essential for the future welfare of the world (Momete, 2015), as STEM professionals will be the builders of forthcoming reality. The importance of STEM skills for boosting economic growth and labour market represents a reality in European Union (EU28) and United States of America (US), as revealed by many motions and reports (European Commission, 2014; United States Department of Education, 2016). The demand for STEM skills is likely to increase, but the quantity and quality of the supply was reported to decrease (Royal Academy of Engineering, 2017). This has the potential to cause a major problem for the EU28 competitiveness, creating a skill gap in the region's economy which is based on innovation and technically driven business processes (Joyce & Dzoga, 2012).

The Competitiveness Report of 2018 places Romania on the 68 position among 137 countries of the world (Schwab, 2017) and on the penultimate from the EU28. Croatia is last within the EU28 space, having the as the most problematic factor the government bureaucracy, while Romania has as the most problematic factor the tax rates. Romania is last in EU28 for innovation and sophistication factors, with a very low availability of scientists and engineers, of only 1.6% from its active population in 2017 (Eurostat, 2018a). Therefore, this paper originally identifies the possibilities to stimulate the students to select a career path based on STEM and is mainly focused on Romania's example.

2. Problem Statement

This paper aims to show that STEM education is important for the future generations, as they will represent the builders of forthcoming world. This research adds to the body of knowledge the identification of barriers, opportunities and key priorities aimed to stimulate STEM education in Romania.

3. Research Questions

The research answers the questions regarding the selection of STEM topics as a career path:

- Question 1: Which is the European/Romanian context of STEM? – Result 1: statistical analysis that proves that STEM topics are selected by only about 30% of student population within EU28 and Romania, and are mainly dominated by men.
- Question 2: Which are the barriers in pursuing an education based on STEM topics in Romania? – Result 2: identification of actual barriers faced by STEM education in Romania, grouped under 5 main groups which were originally identified by the author.
- Question 3: Which are the main actions required to overcome the barriers in pursuing an education based on STEM topics in Romania? – Result 3: identification of novel measures needed to overcome the barriers faced by STEM education in Romania.
- Question 4: Which are the key priorities to stimulate the election of STEM career path in Romania? – Result 4: introduction of a new vision about the stimulation of STEM education, with 6 main key priorities which can be translated into real life.

4. Purpose of the Study

The purpose of the paper is twofold: the paper analyses the main barriers existent for STEM education and identifies the main actions required to stimulate students to select a career based on a STEM topics. The paper contributes with original findings about the stimulation of students to select a career path based on STEM in Romania, exploring the current circumstances and their reasons which are presented in a factor by factor explanation, pointing out the main barriers needed to be overcome.

5. Research Methods

The first part of the research aims to analyse the critical situation regarding the interest in STEM education by briefly exploring its current condition across the EU28. This part shows that the interest in choosing STEM education as a foundation for future career path is confined in all aspects: the number of enrolments, the number of graduates in science and the percentage of tertiary education enrolments and graduates in STEM from the total number of tertiary enrolments and graduates.

The second part of the research assesses the possibilities to stimulate students to select a career path based on STEM and is mainly focused on Romania's example.

The research involves the following steps:

- Analysis of the enrolment/graduation in STEM topics within EU28/Romania: reveals a problematic situation and the need of better ways to stimulate students to select a STEM career;
- Identification of the barriers and measures to overcome the barriers to select STEM education in Romania: presents the actual barriers faced by STEM education in Romania, grouped under 5 main groups which were originally identified by the author, and the identification of novel measures needed to overcome these barriers.
- Identification of key priorities to stimulate STEM education in Romania: introduces a new vision about the stimulation of STEM education, with 6 main key priorities.

6. Findings

This research has as main results the analysis of the EU28 context, the original identification of barriers, main measures to overcome these barriers and of key priorities aimed to stimulate the STEM education in Romania. This research shows that a new vision is needed for the support of STEM education, starting from primary education, which also implies the building of a community network, having as centre the school.

6.1. Analysis of the enrolment in STEM topics within EU28

Within the EU28 there were about 19.6 million tertiary students enrolled at the end of 2016, studying for Bachelor's, Master's and Doctoral degrees (tertiary education levels 5-8). Within these enrolments, only 3 million were studying a field in engineering (engineering, manufacturing and construction), representing only about 15% of the total. Among these, only 26% women were studying for engineering programs, and 4% were studying in information and communication technologies (see Table 01), showing that engineering is still a field of education dominated by men.

In Romania, there were 535,218 students enrolled in tertiary education in 2016 (levels 5-8), placing the country on the 9th position among the EU28 (Eurostat, 2018b). Among these, 118,621 were enrolled in engineering, manufacturing and construction (22% of total enrolments), 27,385 were enrolled in natural sciences, mathematics and statistics (5% of total enrolments), and 32,661 were enrolled in information and communication technologies (6% of total enrolments).

Table 01. Enrolments in 2016 in STEM topics in EU28.

| Topic | Number | % from total | Men | % men | Women | % women |
|--|-------------------|--------------|------------------|-----------|--------------------|-----------|
| Engineering, manufacturing and construction | 3,010,119 | 15 | 2,227,576 | 74 | 782,543 | 26 |
| Natural sciences, mathematics , statistics | 1,546,046 | 8 | 660,910 | 43 | 885,136 | 57 |
| Information and communication technologies | 808,488 | 4 | 772860 | 96 | 35,628 | 4 |
| Total number of enrolments in STEM topics | 5,364,653 | 27 | 3,661,346 | 68 | 1,703,307 | 32 |
| Other fields | 14,225347 | 73 | n.a. | n.a. | n.a. | n.a. |
| Total number of enrolments (levels 5-8) | 19,590,000 | 100 | 9,009,704 | 46 | 10,580,2 96 | 54 |

Source: data calculated from (Eurostat, 2018b). n.a. – not available.

6.2. Analysis of the graduation in STEM topics within EU28

Within the EU28 the number of graduates in a field of engineering was of about 667,000, representing only 15% of the total number of graduates of tertiary education (levels 5-8) in 2016. Among these, only 28% women were graduates from engineering programs, and 19% were graduates in information and communication technologies (see Table 02).

The tertiary education attainment was of about 26% in Romania (persons of 30-34), at the end of 2016, compared to almost 40% for EU28, being the lowest from the EU28. At the same time, adult participation in learning for persons of age 25-64 (levels 0-8) was of only 1.2%, compared with the EU28 of about 10% (European Commission, 2017). These very low figures are to be correlated with a very low investment in education, the lowest from EU28, of only 3% of gross domestic product (GDP), compared with EU28 mean of about 5%.

In Romania, there were 121,788 graduates in tertiary education (levels 5-8) in 2016, placing the country on the 7th position within the EU28 (Eurostat, 2018c). Among these, 22,098 were graduates in engineering, manufacturing and construction (18% of total graduates), 6,950 were graduates in natural sciences, mathematics and statistics (6% of total graduates), and 5,992 were graduates in information and communication technologies (5% of total graduates).

Table 02. Number of graduates in STEM topics in 2016 in EU28.

| Topic | Number | % from total | Men | % men | Women | % women |
|---|------------------|--------------|------------------|-----------|------------------|-----------|
| Engineering, manufacturing and construction | 666,697 | 15 | 481,862 | 72 | 184,890 | 28 |
| Natural sciences, mathematics, statistics | 341,697 | 8 | 159,447 | 47 | 182,250 | 53 |
| Information and communication technologies | 156,115 | 3 | 126,705 | 81 | 29,410 | 19 |
| Total number of graduates in STEM topics | 1,164,564 | 26 | 768,014 | 66 | 396,550 | 34 |
| Other fields | 3,309,266 | 74 | n.a. | n.a. | n.a. | n.a. |
| Total number of graduates (levels 5-8) | 4,473,830 | 100 | 1,893,903 | 42 | 2,579,927 | 58 |

Source: data calculated from (Eurostat, 2018c) n.a. – not available.

6.3. Identification of main barriers and measures to overcome the barriers to select STEM education in Romania

The children of today's society experience technology from the early age differently than two decades ago. The real train/car and the doll/cooking set were replaced by the virtual games played at tablet, laptop, Play station and Xbox One. Therefore, the technology and hands-on activities should be introduced from early education, if STEM education path is to be stimulated.

Barrier 1: Cultural. The main barrier is connected with an erroneous stereotype that connects STEM with difficult, arid and boring topics. On the contrary, the STEM topics are linked with innovation and creativity, therefore are to be promoted as expeditions of discovery from primary school. This is to be achieved by an attractive manner of teaching mathematics and science topics, with hands-on activities and practical examples which are to be an inspiration for every pupil. This implies up-to-date training programs for teachers, both for the content and teaching methods, which incorporate technology through on-line applications and project-based, team-work assignments.

Barrier 2: Structural. The pursuing of STEM education and career path involves at the same time investment in STEM facilities in schools, like experiment kits designed for children, science laboratories that are connected with the real world examples and IT-based teaching/evaluation methods. Moreover, the investment in new tools like rapid prototyping should be thought in order to help the pupils better represent the reality.

Barrier 3: Motivational. Fun activities based on STEM, like science clubs, young mathematicians clubs, special events connected with science (like science fairs, maths festivals, science debates, protecting the environment activities, contests for young scientists) are to be better developed in every school from Romania. This involves their integration in the school daily schedule, and their development inside the schools. In such a way, by smart playing, both boys and girls, very bright and average pupils will have the opportunity to be involved in STEM topics.

Barrier 4: Political. The next barrier is linked with the disconnection existent between government policies and industry/business. There is a need for the policy makers to be more involved in stimulating the relationship among schools and practice in specific industries/businesses, and this is to be addressed by a

better education policy, more oriented on practice. Moreover, the payment of teachers should be considered with priority, as despite an increase, it remains low and drives the teachers to other more profitable activities. This in turn leads to unenthusiastic, less prepared teachers, unable to inspire the young minds.

Barrier 5: Personal. The STEM professionals are perceived as hard working, but at the same time their profession in Romania is not correlated with a financially rewarding career. As self-esteem is mainly correlated with the financial part, it is obvious that the pupils are more attracted to other better remunerated professions.

6.4. Identification of key priorities to stimulate STEM education in Romania

Therefore a new vision is needed for the support of STEM education in Romania, from primary to tertiary education which involves a sustainable partnership on long-term. This vision includes the implication of multiple stakeholders, from teachers to industry, from policy makers to local communities.

Key priority 1: Redesign the school. The school is to be redesigned, as a part of a community network that connects each school with the neighbouring businesses, museums, community organizations, public libraries and mentors. Mentors may be scientists, engineers, entrepreneurs visible in mass-media and from the neighbourhood, if possible, in order to create a larger impact on the children activities. Each mentor should adopt a school and should inspire the pupils by active involvement, as guest lectures and facilitating site visits, during the whole school year, not only at the beginning and end of it.

Key priority 2: Improve curricula for STEM. The policy makers specialised in education but also in science, technology and research should work together with teachers associations, parents associations and inspectorates, to create better curricula for STEM topics. The first issue to be tackled is to think curricula for primary and secondary education based on understanding, scientific observation and personal experimentation, not on over-stuffed text-based topics as in present. The learning experience should be enriched with collaborative problem-based learning (Momete, 2016), scientific experiments and debates.

Key priority 3: Increase investments. Local authorities should be more involved in the school activities and should work in collaboration with the previously mentioned stakeholders, as the primary education requires a systemic approach. Local authorities should invest in STEM facilities in schools and IT-environments.

Key priority 4: Improve teachers' training. The teaching and learning dimension is to be next tackled, by establishing better training programs for primary school teachers on STEM specific disciplines and how they must integrate STEM-disciplines with other non-STEM disciplines. Moreover, the actual tackling of STEM-disciplines by teachers from primary to secondary education should facilitate the development of an authentic learning ecosystem, where the online collaboration applications designed for children, interactive digital games and technology-enabled tests are to be incorporated into the learning experience.

Key priority 5: Motivate through fun activities. The fun part based on STEM activities should move away from leisure time to school time, as this may act as a motivation tool for average and sub-average pupils. The universities should be also involved and organize science workshops, summer schools based on hands-on activities designed for young pupils, as the orientation towards STEM topics should start from an early age.

Key priority 6: Attract and reward qualified teachers. The qualified, talented and enthusiastic teachers should be attracted in the primary and secondary education, as they may act as inspiration for pupils to select a STEM career. This is to be achieved mainly by better salaries and rewarding systems for teachers. At the same time, the salary framework in Romania should be reconsidered and should incorporate the value of the work and not special salaries and special pensions for some categories.

In such a way, the real world will be introduced in the classroom by the involvement of all the stakeholders which may help the schools to develop activities inside and outside the classroom that are showing the pupils the world that lies beyond the classroom windows and its functioning. Given the skill shortages, especially in STEM professions, and continuous emigration of Romanians (European Commission, 2017), the excellence in education, from primary to tertiary, should be pursued with consistency and determination and this may be also achieved by tackling the priorities identified by this paper.

7. Conclusion

The first step in addressing the global complex challenges facing humanity today, ranging from climate change and biodiversity loss, to sustainable energy usage and pollution control, from food and water security to global health and aging population, is a major change in education, especially for STEM topics.

The stimulation of STEM education is a complex and many-sided problem. Although several initiatives were followed by few schools in Romania, mainly private schools, these islands of creativity and innovation should be linked and should become the main stream for state and private schools alike. The school must not be regarded as an island, disconnected from the everyday life, but a very important element of society which should be linked within a community network.

The findings of this paper may be used as best practices to be pursued by policy makers, industry facilitators and schools and universities in order cope with a more competitive world, where the supply and demand of STEM qualified professionals is to be better matched.

This paper opens a line of research which will be further explored by the author in evaluating key performance indicators for the best motivation drivers employed for STEM education within EU28.

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