STEM Education in Europe & the PISA Test

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Abstract: The 2018 Pisa (Programme for International Student Assessment) test results, which were announced in December 3, 2019 (Sleicher, 2019), showed no progress in the EU students' performance in Mathematics and Science (European Commission, 2019). From 2000 to 2015, the advancement of STEM (Science, Technology, Engineering and Mathematics) Education has not been very encouraging. In the 2018 Pisa test, the situation remained static despite the EUN's (European Schoolnet's) ongoing activity during the last few years in Europe (Billon et al. 2019). The continued enlargement of the European Union, the different national curricula of the EU member states and the increase of the immigrant and refugee flows have contributed to the recorded stagnation. STEM education, involving an integrated approach to teaching Sciences in conjunction with an Enquiry-Based approach to learning, is directed at developing students' problem-framing and problem solving skills as well as their ability to contextualize scientific concepts in real-life situations. The object of this article is to monitor the progress of STEM Education from 2000 to 2018 and to assess the way that the increase of EU student interest in STEM subjects is measured by taking into account the underachievement of fifteen-year-old students in Mathematics and Science (Titin-Snaider et al., 2018) as well as the achievement of the SDG4 (Sustainable Development Goal 4) goal for quality education and sustainable development (Unterhalter, 2019).

Keywords: STEM Education, Pisa Test, SDG4, European Schoolnet

Introduction

In the USA, from 1990 to the present, the STEM sector has grown attracting even more new scientists to join the STEM work force at a much higher rate and with higher salaries (US Department of Labor, 2019). In China, the percentage of young people studying in STEM-related academic departments has quadrupled between 2000 and 2012 (National Science Foundation, 2018).

In contrast, in the EU-27, more than half of the countries had a lower-than-average score in the PISA (Programme for International Student Assessment) test, Science and Mathematics (OECD, 2009). Figures show that, in developed countries, students, aged 13-15, have a de-

creased interest in science, technology, engineering, and math lessons and that they do not think seriously about pursuing a relevant career.

The Rocard report on science teaching argues that good practices are bound to act as prerequisites for a dramatic change in the interest of young people. In fact, it would be a good idea if education, industry and politics joined forces to create professional experts who will be able to respond to future work needs in STEM training by filling key positions (Rocard, 2007).

What can be derived from the above, countries outside the European Union with robust economic growth, like China and the USA, will be able to cover their workplace needs in STEM employees and proceed smoothly. In the EU, the situation is slightly different because young people and especially young female must be convinced to get more involved in Science and Mathematics if they are to fill emergent job positions in the STEM sector.

This article will attempt to set out the situation from 2000 to 2018 according to the OECD (Organization for Economic Co-operation and Development) publications and to elucidate the reasons why there is no significant progress being made in STEM Education even in developed countries.

Although EU invests in education and especially in the STEM sector, there is no tangible progress since the EU is in a constant state of expansion through the simultaneous incorporation of refugees and immigrants (OECD, 2015). What must be made clear is that current progress in STEM Education should be recorded in a different way so that it may be disconnected from the indicator of the 15-year-old underachievement in Mathematics and Science of the Pisa test. The above low performance indicator is associated with the indicator of achievement of the SDG4 goal for quality education in all EU countries until 2030.

A major factor affecting the students' performance in the Pisa test as regards Science and Mathematics is the different way of teaching STEM subjects adopted by the different educational systems of the member states because of the significant differences and directives contained in their national curricula. The most predominant practices affect the students' performance.

The evaluation of the statistical results developed by the OECD indicates that there is delay in the decrease of the percentage of 15-year-old underachievers in Mathematics and Science. More specifically, although the goal is 15%, the 2015 results show that 22,2% of European students in Mathematics and 20,6 students in Science were not admitted to the third level of the Pisa test (Parveva et al 2018). Nonetheless, this does not entail that there is no improvement in education in the corresponding sector. The newcomer Romania has a percentage of 39,9%, crisis-hit Greece a percentage of 35,5%, EU-28 an average percentage of 22,2% and the U.S.A. a percentage of 29,4% (Eurostat, 2019). Therefore, the focal issue should not be the underachievement of 15-year-old students but good performance standards which will lead the way to STEM-related jobs.

So, wherein lies the question as far as STEM education is concerned? If taken for granted that not much progress has been made thus far, what remains to be done? A painstaking research

and analysis of the data about education will give us access to the bigger picture about the progress achieved in the last few years so that Europe can take the next step. In the European Union, it is believed that networking (Scimeca et al, 2009), mobility (European commission, 2018) and collaboration between competent authorities (Titin-Snaider et al, 2018) can yield positive results on educational matters which will, in turn, lead to economic development and social cohesion. Despite any difficulties that may arise, there is one goal we should never lose sight of and that is Sustainable Development.

1. Body

1.1 Method

This article is based on the most recent statistical studies carried out in the countries of the European Union in recent years aiming at the review of the situation regarding Science and Mathematics teaching. The four main organizations involved in the above issue are the European Commission, the OECD, the EUN and Eurostat. Individual statistical studies have been used from other organizations as well.

To begin with, there is a detailed account of the trajectory of progress in EU countries with different national curricula in education and a different approach to Mathematics and Science teaching problems. Subsequently, there is a presentation of the general picture espoused in the EU-28 with an emphasis on the fact that the goals for quality education and sustainable development are still at arm's length. Finally, after the presentation of the EUN's activity on STEM Education follows a commentary on the way progress in STEM Education is recorded and on the extent to which the aforementioned way constitutes a failsafe indicator leading to the following steps to be taken.

The outcome of this study will bring to the fore that the activity developed in the EU on the progress of STEM Education must be continued and systematized for individual member states via the creation of a prioritization framework in relation to the wanting sectors so that each country can do things at its own pace towards securing the sustainability of Mathematics and Science instruction.

1.2 Results & Analysis

1.2.1 Pisa test

In December 3, 2019, the 2018 Pisa test results announced by OECD did not show significant differences for the countries of the EU-28. The SD4 goal of the EU for quality education was not achieved since the percentage of the fifteen-year-old students who were not admitted to the third level of the Pisa test exceeded the 15%. Despite fluctuations in the countries' percentages, there is stagnation in Mathematics and Science.

Table 1. Underachievement in Science & Mathematics percentage (%) 2009 – 2018

Time	**2009**		**2012**		**2015**		**2018**	
Field	**Maths**	**Science**	**Maths**	**Science**	**Maths**	**Science**	**Maths**	**Science**
Geo								
EU 28					22,2	20,6	22,4	21,6
EU 27	22,3	17,7	22,1	16,6				

Estonia, Poland, Ireland and Finland have attained the goal while Denmark is close to its attainment. In the remaining countries, from 2009 to 2018, the indicator for Mathematics and Science has declined slightly compared to Romania, Bulgaria, Cyprus, Greece, Croatia and Malta (OECD, 2019). These countries are recent newcomers to the EU, hence their need of a period of adjustment to the European legislation, or they are countries in the process of exiting the economic crisis.

An influencing factor determining the students' performance in the Pisa test are the immigrant and refugee flows. There is a large performance gap in the percentage of the 15-year-old underachievers between those who are national residents and those who have an immigrant background even in countries with good performance standards in the Pisa test. (European Commission, 2018).

Table 2. Low performers in reading among students with immigrant background %

Country	**%**
Albania	87,6
North Macedonia	65,5
Bosnia and H	62,5
Bulgaria	61,9
Slovakia	51,4
Greece	48,3
Netherlands	43,5
Montenegro	40,2
Finland	39,9
Austria	39,9
Sweden	37,9

Additionally, the countries which are expected to enter the enlarged EU do not have good percentages in the aforementioned indicators; thence, they will cause low student performance in Mathematics and Science to increase. Albania, Northern Macedonia, Serbia, Montenegro

and Bosnia share low percentages in Reading, Mathematics and Science, so the situation will get worse.

Table 3. Students performance in reading PISA test 2018

Country	Mean score
Albania	405
Bosnia and H	403
Montenegro	421
North Macedonia	393
Serbia	439

To sum up, from 2009 to 2018 student achievement in Mathematics and Science is stagnant except for the case of the indicator of Science in 2012 which approached the goal of the 15%.

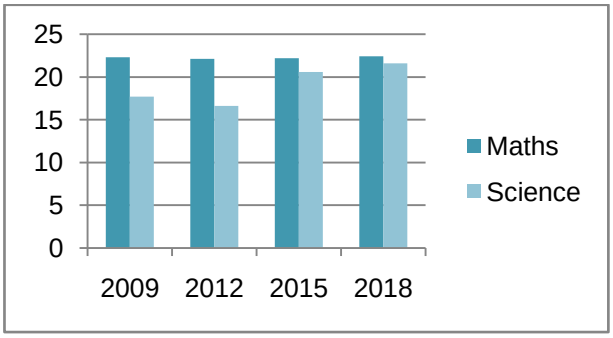


Figure 1. Underachievement in Science & Mathematics percentage (%) 2009 - 2018

1.2.2 The European Commission

According to the Eurydice observatory since 2009, the European Council approved the increase of the engagement with basic skills with a view to reducing the percentage of fifteen-year-old underachievers in Reading, Mathematics and Science to less than 15% until 2020. Nevertheless, the non-satisfying performance in the Pisa test keeps on posing a serious challenge to the entire Europe (Parveva et al, 2018).

In the EU, the promotion of education is of vital importance. Quality education does not only account for the economic development, social cohesion, research and innovation but also leads to a dramatic change of the citizens' prospects for personal development (European Commission, 2019). The European Commission, by insisting on the promotion of the science-oriented STEM culture in order to carry on with the activity which had been highlighted in the previous decade (Gago, 2005), launched the "New Skills Agenda for Europe". This compilation of ten actions is addressed to the 70 million Europeans who are deficient in basic reading skills, numeracy and digital competencies as well as to the 12 million unemployed. (European Commission, 2016).

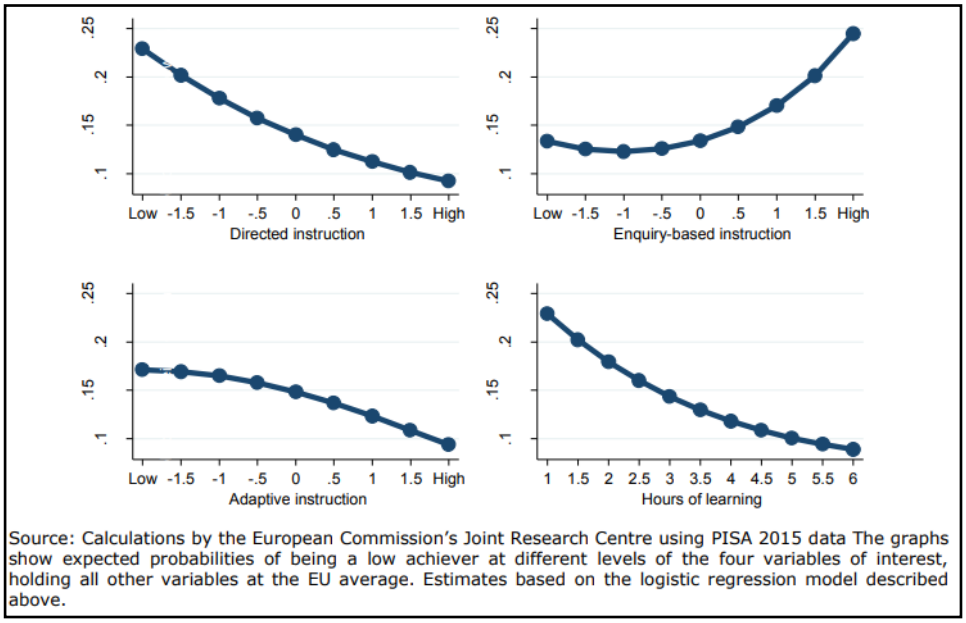
Via the support of the European Commission, Denmark has made a significant effort to guide students and parents with the help of the project called 'STEM - the way to business competence and employment'. The collaboration among educational bodies, i.e. vocational schools, is aimed at motivating students to select STEM Education for future study or career. It is possible even for adults to participate in the project in order to further improve their skills, be gainfully employed and/or develop professionally (European Commission, 2019).

In this way, the European Commission is an active participant in the in-depth evaluation and analysis of the statistical results concerning general education focusing on STEM Education on an equal basis. In the 2018 Education and Training Monitor (European Commission, 2018), it is pointed out that the ways of teaching STEM subjects have an effect on the SDG4 indicator and the development of STEM Education.

Table 2. Teaching practices/strategies for science

Science instruction	Description
Teacher-directed	Well-structured and informative lessons that include teachers' explanations of concepts, classroom debates and students' questions
Enquiry-based	Science activities that lead students to study the natural world and to explain scientific ideas by engaging in experimentation and hands-on activities
Adaptive	Teacher' flexibility in adapting the lessons to students with different knowledge and abilities

What is of particular interest in the following diagrams is the impact of the Science teaching techniques on the probability that a student will not pass the second level of the PISA test and will be characterized as underachiever.



Source: Calculations by the European Commission's Joint Research Centre using PISA 2015 data The graphs show expected probabilities of being a low achiever at different levels of the four variables of interest, holding all other variables at the EU average. Estimates based on the logistic regression model described above.

Figure 2: Relations among the probability of being a low achiever in science, three types of teaching practices and hours of learning

The directed and adaptive instruction in conjunction with the increase in teaching time generally reduces the probability that a student be characterized as underachiever while the Enquiry-based instruction does not have the same results. When Enquiry-based instruction is used in small percentages, the probability under discussion is reduced, while in the case of large usage percentages it appears to cause problems for students with low performance impeding the goal achievement.

While Enquiry-based instruction does not favour underachievers, it contributes to the development of STEM Education which entails not only that its use by educators should be targeted at the average student but also that a combination of techniques is more likely than not to produce better results for all students.

The participation of Europeans in tertiary education proves that even countries with underachievement in the PISA test have attained the EU goal by means of a satisfying student increase from 2005 to 2018 (Eurostat, 2020). 43% of the 4,259 graduates of 2017 have been involved in STEM subjects like Mathematics and Science, ICT, Engineering, Agronomy and Health. In conclusion, almost half of the European graduates are involved in the STEM sector (Eurostat, 2019).

1.2.3 EUN's & other organizations' activity

At the end of 1996, subsequent to a presentation by the Swedish Minister of Education during a meeting of Education Officers coming from the Ministries of Education of EU countries, the Swedish Ministry of Education invited organizations that were interested in participating in a

European network to submit a proposal to the European Commission. That invitation signaled the official beginning of the EUN's activity. (Leask &Younie, 2001).

EUN's Project Manager, Dr Agueda Graz, in her presentation in Warsaw, in September, 2014 during the "STEM Educators Academy" conference (the first conference on STEM Education in EU) gave information about: eTwinning which is about linking schools, InGenious, later renamed into STEM Alliance, which is about developing STEM Education, and Scientix which is about promoting collaboration among educators, researchers, policy officers and other professionals. According to her, these are the three main courses of action planning through which STEM Education is developed in the EU. The EUN's activity as this is recorded in the last Scientix update (Billon et al. 2019) has had very good results as it is based on the three-fold objectives: networking, collaboration and mobility.

EUN's immediate goals are to give educators access to the new educational projects, its provision of high level quality resources and to the reports and news about STEM Education as well as to encourage them to share good practices (Billon et al. 2019).

2000 is not only the chronological point of reference when great effort was put into rekindling the students' and teachers' interest in Mathematics and Science with the support of EU (Horizon 2020), but also the year which gave birth to a network of NCPs (National Contact Points) and Scientix ambassadors supported by the Ministries of Education of the 34 countries collaborating with the EUN. The Horizon 2020 Programme has invested around 80 billion euro for the 2014-2020 period to be spent on innovation and sustainable development (European Commission, 2013).

The most important action in education is teacher training. The EUN gives priority to this action by organizing a great number of training and professional development opportunities. Moodle courses, webinars, MOOCs, workshops, conferences and competitions are organized throughout Europe providing participants with thought-provoking experiences which aid them in altering their attitude towards the teaching of Mathematics and Science.

The STEM Coalition (Asselbergs, 2019) network is considered a parallel to that of Scientix network which supports the coordination and the application of a national strategy for STEM Education and the job market, while the STEM Monitor Programme (DepartementOnderwijsenVorming, 2019), is an action plan conceived by the Flemish government in cooperation with the European Commission which monitors the STEM action in accordance with specific indicators.

2. Discussion & Conclusions

The PISA test constitute a one-dimensional recording of the present situation in world education which, as it turns out, have been converted into a racing competition as to which country will finish first. China's first place this year owing to the rearrangement of the provinces from which participant students came from (Liu, 2018) as well as Turkey's impressive progress

(OECD, 2019) make us puzzle over the experimentation with the sample and the possibility of a concealed in a simple test for students expediency. What is more, research is scarce on the efficacy, adequacy and general value of a PISA test (Zhao, 2019). Besides, the research in education should not focus solely on the indicators for Reading, Mathematics and Science, but also on the social skills developed in the school unit.

It has been proved that not only does the standard and extensive classroom-based application of Enquiry-based learning not improve underachievement, but may turn out to be a contributing factor to its consolidation. For this reason, there should be no causal correlation between the underachievement of fifteen-year-old students in Mathematics and Science and the development of STEM Education.

Every EU country is in the process of establishing an individual action plan which will facilitate young people's route to Mathematics and Science within the broader commitment framework towards the European Commission. The role of the European Commission is to show the way while the role of the involved parties is to follow in their own way. In this respect, the EUN's and other organizations' activity is pertinent to the established standards and has very good results. What should be taken into serious consideration is that the EU enlargement complicates things further, mainly because the Balkan and Eastern European countries have a long way to go.

The situation in the job market related to STEM shows that the employment rate of STEM-skilled manpower is on the rise, despite the economic crisis, and is expected to keep on rising because of the growing demand. At the same time, a large number of STEM professionals are approaching retirement age. Around 7 million job openings are expected until 2025. The demand for STEM skills requires specialized training in both secondary and tertiary education (European Parliament, 2015).

The immigrant and refugee flows will continue. The young people coming from developing countries migrate with a view to looking for a better future in developed countries. Although nations invest a lot of money in youth training, young people move abroad for work instead of staying behind to fulfill the norm of reciprocity. Immigrants and refugees from all over the world enter Europe either legally or illegally. Europe is the epicenter of political developments with border conflicts taking place close by and with the relationship of EU member states remaining economic instead of entering the process of European integration.

The educational institutions should abide by the principles of democracy, equality and social integration whilst maintaining their independent character. A higher participation of preschoolers is another important aim. What holds true in respect of education is that changes take effect only gradually because involved parties have difficulty becoming aware of the road to be taken from the outset. The question to be posed at this point is whether it is ethical to direct students' attention towards Mathematics and Science by deviating it at the same time from Humanities and Social Sciences which are considered to promote and preserve culture.

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