

The Status of Natural Scientific Education and its Relationship with Exam Systems

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Abstract—According to international surveys (PISA, TIMSS), the mathematical and natural science test results of the Hungarian students have been steadily declining. The number of those who are affected by school dropouts is high. The present educational methods are not able to prepare the students properly for measures requiring application-oriented knowledge. In the hierarchy, natural science subjects are considered to be the least popular and significant ones among students. Compared to the 1970s and 80s, the natural sciences have become the ‘great losing side’ due to the lessons’ number changes of the consecutive National Core Curriculum. The low lesson number is not in balance with the huge amount of educational material to be learned. There is not enough time to perform experiments, to deepen knowledge, to have student-centered methods. Based upon the core points of the new National Core Curriculum, a piece of extensive scientific knowledge and being able to solve problems are the most fundamental skills to be developed, however, the viability of the implementations has not begun to take shape. The Final exam is the most influential output element in our examination system. Presently, only a few students tend to choose science subjects for their Final examination, moreover, few people take an advanced level exam in these fields. Fortunately, from this year, it is compulsory to take an advanced level examination of at least one subject to enter higher education. Nowadays there are not any obligatory science subjects for the Final examination, however, their introduction is a prevalent topic among professionals. Several people hope that, by the new examination, the level of students’ motivation for the subject and the general knowledge of the society can be increased. In 2019, the authors made a survey. They elaborated questionnaires for teachers and students about the effect of the exam on students’ motivation and knowledge. They expected a high level of acceptance of an introduction of compulsory science subjects for the Final examination. It is a promising result that the majority of students and teachers find science knowledge important. Unfortunately, the popularity index of these subjects is still low; this means that we have to find solution for improving the teaching-learning process.

Keywords—STEM, Final examination, National Core Curriculum, international surveys, natural science subjects.

1 Crisis in the Education of Natural Sciences

The education of natural sciences is in a century long handicap compared to human subjects. It appeared in the 19th century in the school curriculum, but initially, it was present exclusively in secondary education. After the Second World War natural sciences were more and more appreciated and owing to this, they started to appear in the curricula. Retrospectively, we might say today that the education of natural sciences in Hungary had its heyday in the 1970s and 1980s [1]. Since then, even if environmental protection has come into the foreground, technical development has speeded up and these could have strengthened the position of natural sciences, decline is more characteristic.

In recent years, not only professionals dealing with natural sciences but teachers also sense that the field is in crisis and something is just not right concerning scientific education. What are the main signs of crisis?

- In Hungary, recently, the crisis of teaching science has been sensible in several fields [2]. The results of international measurements (PISA, TIMSS) [3], [4] concerning Mathematics and Natural Science tests have been continuously deteriorating. It is particularly worrisome that if we study the international measurements, we can see that the ratio of those lagging behind has been increasing yearly. It might contribute to our weakening result that the values, on the basis of which the measurements are conducted, have changed. Instead of focusing on knowledge, more and more applicability comes into the foreground, at which, for the time being, our education system is not strong enough.
- The natural scientific subjects are positioned at the end of the popularity lists. Mostly the acceptance of Chemistry and Physics is unfavorable.
- The average scientific education level is low. Unfortunately, the lack of knowledge gives rise to the spread of pseudo sciences and to the intensification of deception.
- Few students choose scientific subjects for the school leaving final exam especially on advanced level.
- Few people choose a scientific profession. According to the 2019 report of the European Committee [5], the ratio of those graduating from Mathematics, IT, Technical Studies, Engineering or Building Industry, especially those completing a master or PhD is one of the lowest in the EU. Concerning educational aspects, the situation of scientific teacher training is particularly troublesome. The average age of professional staff is high and according to prognosis, 50,000 teachers will retire within the next ten years.
- There is a growing lack of professionals. The increasing lack of scientific professionals has appeared as the obstacle of economic development.

These problems of listed crisis symptoms appeared not only in Hungary [6] or European Union, but in Canada [7] and USA [8] as well, and these nations have been also trying to find the best solution of improvement of STEM education.

The causes of the crisis are rooted deeply and can affect very diverse areas, including social, economic and political questions as well. In the current framework, we have

tried to search for reasons linked to education and education policy. One possible reason is the number of lessons provided for the education of scientific subjects. We can state that natural sciences are the ones who suffer the most from the changes of the number of lessons in the consecutive National Core Curricula. When the National Core Curriculum was introduced in 2002, the number of natural sciences lessons was decreased with 15%. Among natural scientific subjects, Physics and Chemistry endured the biggest loss. Parallel with the number of lessons, the question of content, what we teach and what output we expect, is also very important. After the changes in the curriculum, unfortunately the content was not developed according to the new situation, and the new numbers of lessons were not harmonized with that. There is not enough time for practical training and deepening the theoretical knowledge. The other problem is the lack of harmonization of the curriculum content of certain single subjects. Regrettably, in case of the present curriculum, in many cases, the temporal harmonization of certain cross-curricular connections has not come into realization, the single subjects and subject contents do not overlap.

Naturally, the provided content is just a framework, in order to have a suitable interpretation, the appropriate methodological preparation is needed. Unfortunately, not many teachers recognized that new methods are needed in order to gain the attention of current “z” and “alpha” generations. Moreover, the student-centered methods would claim more time but opportunities are less and less given to achieve this.

The newly elaborated National Core Curriculum did not increase the number of lessons but they integrated some independent subjects into a comprehensive natural science subject.

As a cause of the crisis, the present exam system and its expectations can emerge. Exams have a growing role in the regulation of educational processes. An exam is always the closure of a learning procedure and, on many occasions, it is a prerequisite of entering a new procedure. In our current educational system, the most significant exam is the secondary school leaving final exam. In Hungary, this final exam in secondary school is the necessary condition to enter higher education. The system has undergone many modifications. In our present society, many basic questions, such as environmental protection, healthcare, energetics and urban development are interwoven with natural scientific contents; surely a responsible citizen should be familiar with these questions. Contrary to all expectations, it is not compulsory to take a natural scientific subject at the final exam, and proportionally few students select scientific school leaving exams. It has emerged more times in professional circles that the introduction of one compulsory scientific subject as a final exam subject would be needed, though change has not happened so far. Studying the professional literature, the authors formulated two research questions. Can be increased the level of acceptance of STEM subjects in secondary schools? Would be any impact of possible introduction of a compulsory science subject at the final examination? This latter topic and the research question inspired our survey carried out in 2019.

2 Methodology

The goal of the survey was to examine the opinion of students and teachers about increase of acceptance level of STEM subjects in secondary schools and impact of possible introduction of a compulsory science subject at the Final examination. The authors elaborated questionnaires for teachers and students about the effect of the exam on students' motivation and knowledge. Before carrying out the questionnaire, authors established the following hypotheses:

- **H1.** It is important for a student to have STEM knowledge.
- **H2.** Compulsory scientific subject at the school leaving final exam can increase the motivation in students to learn scientific subjects.

The authors expected to prove these hypotheses, in this case general awareness and knowledge level can be increased in the society. Furthermore, more students will choose a scientific or technical carrier or higher educational studies [9].

The structure of questionnaires were the same for teachers and students. They contained 15 questions each. There were multiple selection choice and attitude type questions where authors used five grade Likert scale for evaluation. The first part of questionnaire were the personal data, age, sex and type of school. *In this paper, they focus on the following questions:*

- Is it important for a student to have STEM knowledge?
- Is the STEM knowledge an important part of basic literacy?
- Do you support a compulsory natural science subject at the final exam?
- Do you think the compulsory natural science subject at the final exam improves the popularity of STEM subjects?
- Do you think the compulsory natural science subject at the final exam has positive impact on the knowledge level of STEM?

The authors used Google questionnaire sheets because this method could be quick and provided enough number of answerers. The answers were volunteer and anonym according to the European GDPR – *General Data Protection Regulation*. They targeted minimum 100 answerers both among teachers and students. Results were analyzed on level of significance, correlation, factors used SPSS statistical software. According to the correlation analyze there were not strong connection and significance among the factors. This is why the authors preferred the descriptive statistics for presenting the results.

They tried to manage to get data from the most possible institution types in order to see somehow representative results. There were 193 students giving answers to the questionnaire. 64.1% were girls. It is a higher ratio than in the population of the youth of that age. Probably the girls were more interested in questionnaires and following orders.

There were 103 teachers giving answers to the questionnaire. 79.6% were ladies. Unfortunately, it is not unexpected because 82% of teachers are ladies in Hungary.

3 Results of the Survey

In this part authors are going to review the most important questions of the questionnaire. Answers are presented on figures with bar charts. Every figure consists of two parts: *The first magenta chart always shows the students' opinion and the second light blue one shows the teachers' opinions and answers.*

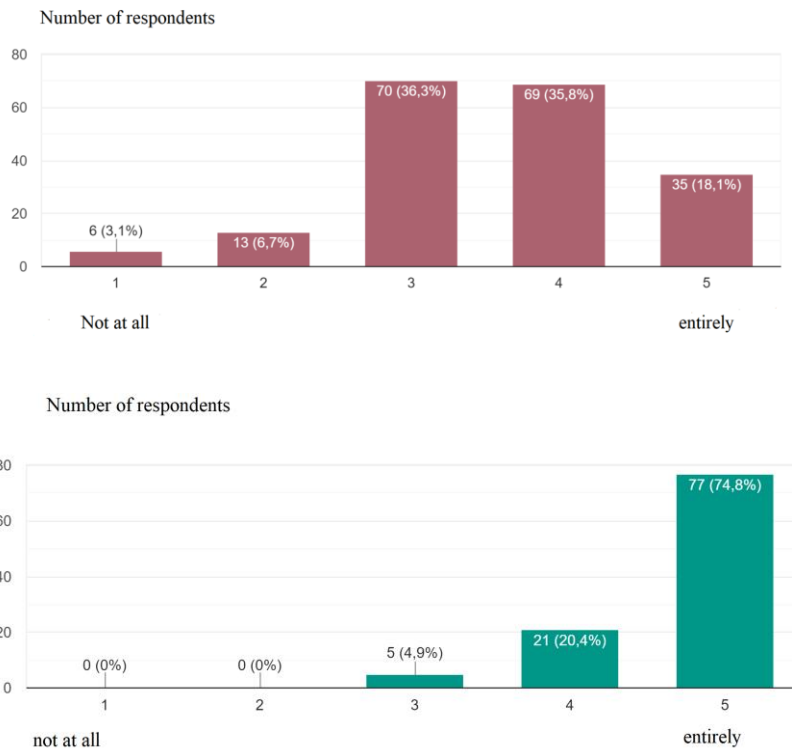


Fig. 1. Is it important for a student to have STEM knowledge?

As the results of Figure 1 indicate, both students and teachers consider scientific subjects and STEM knowledge fundamentally important. This is a valued result because, on a daily basis, the experience is rather the opposite. Three quarters (74.8%) of the teachers answered that they considered scientific knowledge very important, independently from their major teaching field. It was important that nobody chose the “not at all” or “it is less important” options.

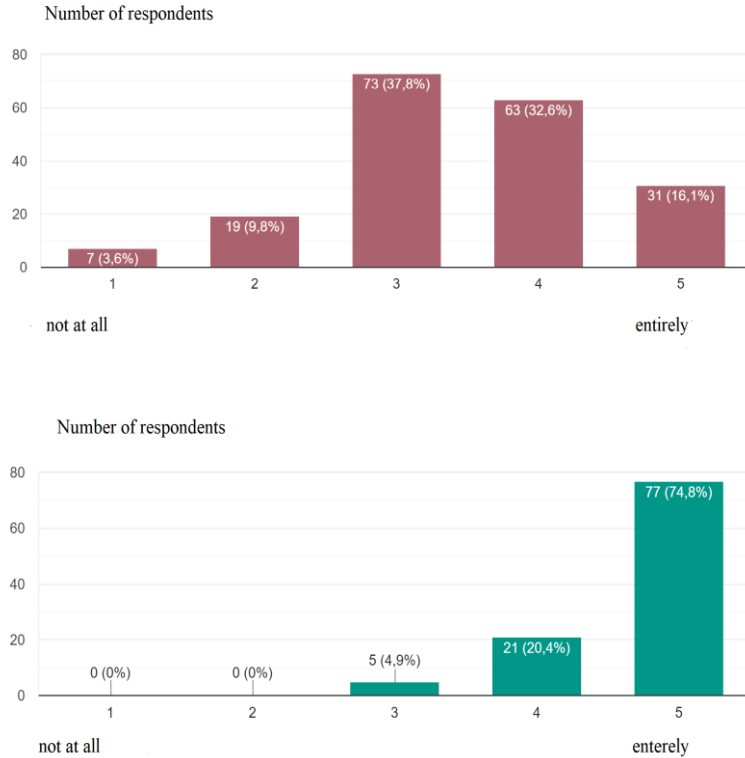


Fig. 2. Is STEM knowledge an important part of basic literacy?

According to Figure 2 there was a big difference between the students' and the teachers' opinion. 74.8% of the teachers entirely agreed that STEM knowledge is an important part of basic literacy. The biggest part of the students (37.8%) thought STEM knowledge is only a moderately important part of basic literacy. Only 16.1% of students agreed entirely that STEM knowledge is an important part of basic literacy. As authors expected, the ratio of those who consider it a part of basic literacy has decreased a little, and that of those who consider it medium level or rather do not feel that it is part of basic literacy has minimally increased. Most probably the reason for this could be detected in the general social presumption according to which people exclusively mean basic literacy as the classic, human intelligence, and maybe language knowledge or some mathematical knowledge.

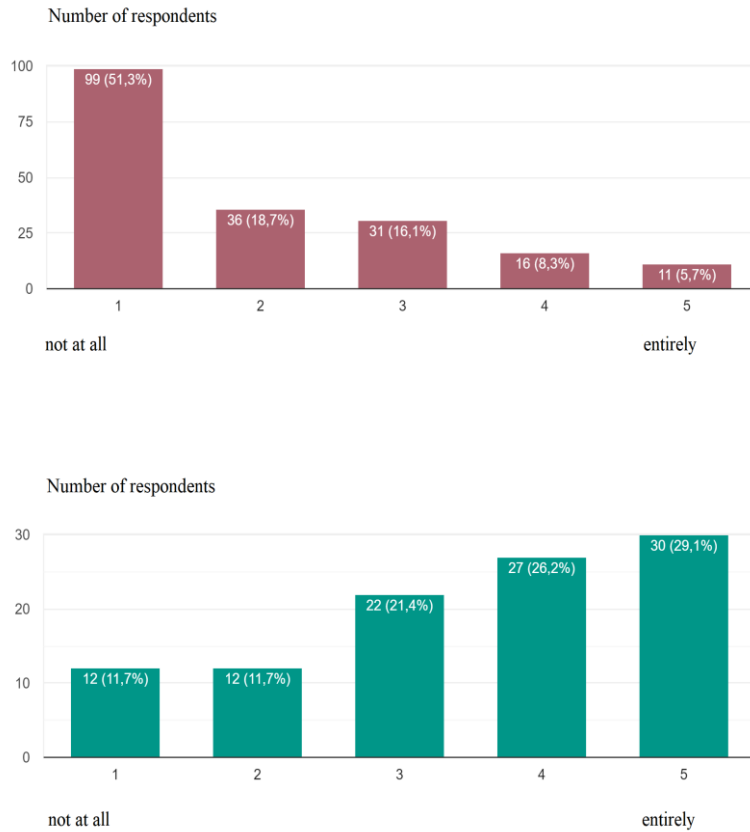


Fig. 3. Do you support a compulsory natural science subject at final exam?

Students are generally very reluctant in connection with exams, so the result of answers by students in Figure 3 is not surprising. Initially, the scientific minded students or those for whom these subjects would be useful in their further education support the introduction. Teachers compared to students would support a possible future scientific school leaving exam to a much greater extent. Naturally, science teachers would be the most welcoming, but teachers majoring in other subjects could also accept the introduction. The tendency comparing students and teachers was the exact opposite. But finally, more than half of the teachers would welcome a STEM subject at the final exam which is a very important result. During the reform of the educational system, this fact should be taken into consideration.

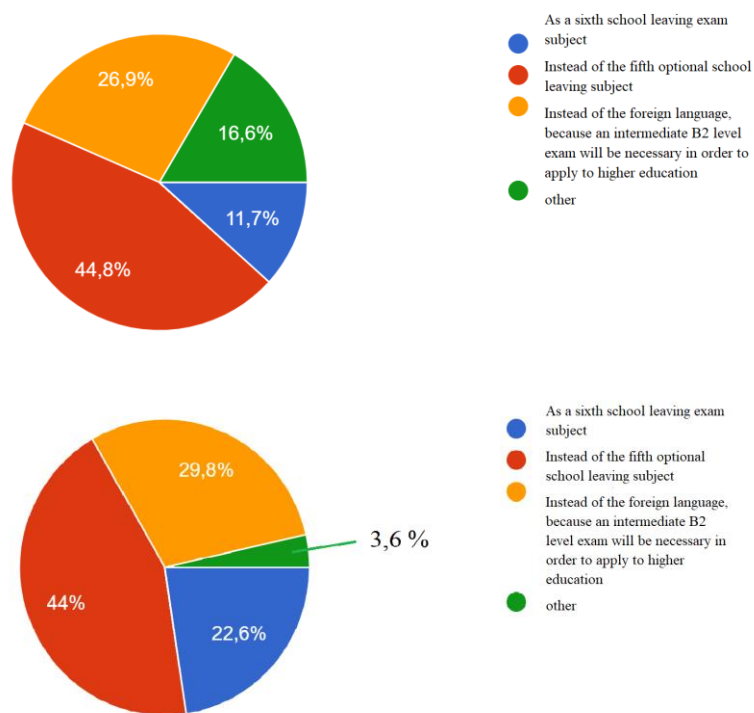


Fig. 4. In what way could you imagine the compulsory natural science subject at the final exam?

On Figure 4 there is an agreement between teachers and students concerning the way of introduction of a compulsory natural science subject at the final exam. The majority of both groups could imagine scientific subjects as the substitution of the fifth optional subject. A relatively great number also sees it possible to introduce the scientific subject instead of foreign languages. This might have happened, because when conducting and carrying out the survey, there was a valid government regulation stating that students needed to have a compulsory B2 level intermediate foreign language exam in order to apply to higher education.

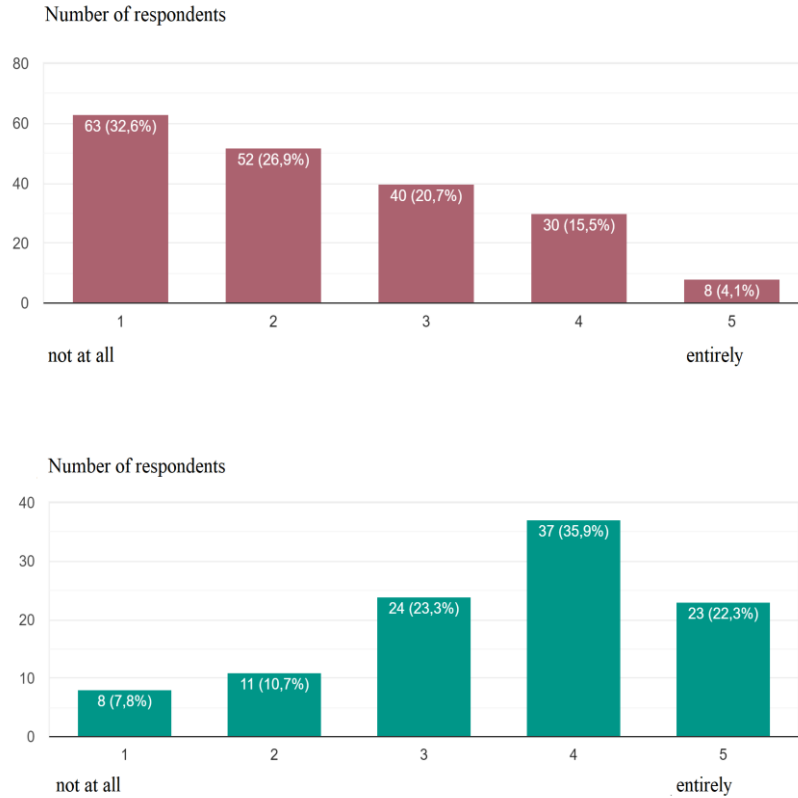


Fig. 5. Do you think the compulsory natural science subject at final exam improves the popularity of STEM subjects?

Figure 5 shows that concerning the exam motivational force, unfortunately our hypothesis was not proved. According to the answers of the students' majority, a compulsory natural science subject at the final exam would not or would minimally improve the popularity of STEM subjects. Teachers' opinion is more positive, it meets our anticipatory expectations. The cause of the difference might be that students rather think about these questions on a short-term basis while teachers might consider them on long-term basis.

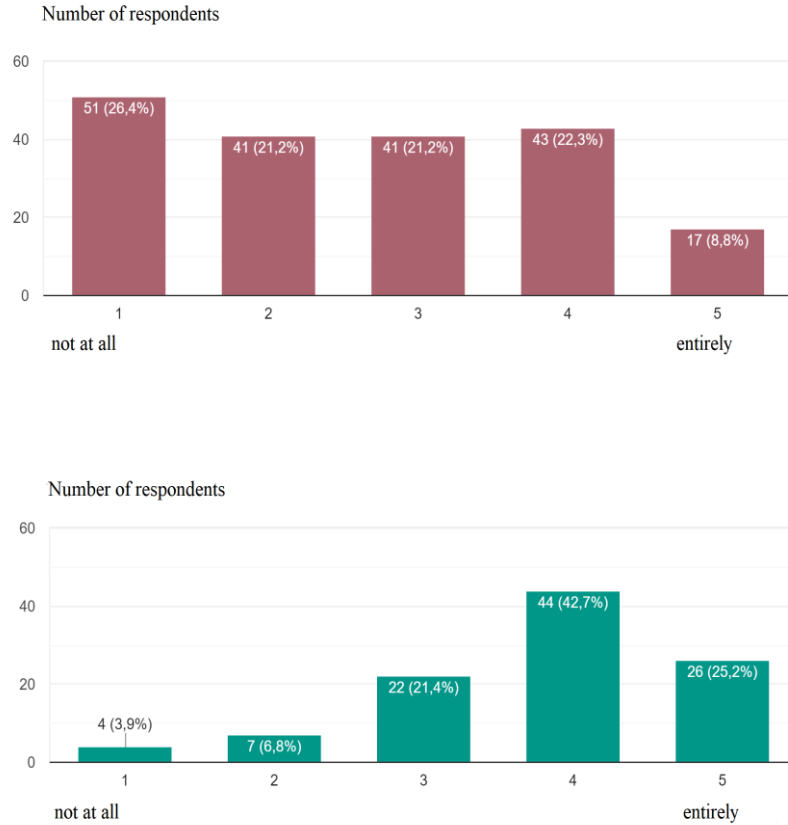


Fig. 6. Do you think the compulsory natural science subject at the final exam has positive impact on the knowledge level of STEM?

According to both groups in Figure 6, a newly introduced compulsory exam subject could have a positive effect on the knowledge level of STEM. This is also an important statement of the questionnaires. Teachers envision stronger and more positive effect compared to students. This confirms the concept that exams can have a positive effect on the teaching-learning processes and they can increase efficiency.

4 Conclusion and Future Work

The authors elaborated two hypotheses. H1 It is important for a student to have STEM knowledge is proved only partly. The STEM knowledge is important according to the majority of students and teachers, but the acceptance of STEM subjects is on low level. It would be important to think about what can be the reason for it. Probably, we

have to change the selection of training content and applied methodology to improve this situation. Nowadays, in public opinion, only the human knowledge is part of basic literacy. Maybe this is the reason why the minority of the students and teachers considers STEM a part of basic literacy, but the majority thinks that STEM is important in their life.

Students refused the possibility that natural science might be a compulsory subject at the final exam. Only those students support this idea who have some interest in STEM or need a natural science subject for their further studies. If the information was practice oriented and closer to the real daily life, the acceptance of STEM subjects could become higher both among teachers and students. In longer term, the popularity of such a subject can be improved. The support of natural science as a compulsory subject at the final exam is higher among teachers than among students. It would be important to take it into account in educational reforms.

Unfortunately, the second hypotheses were not proved. H2 Compulsory scientific subject at the school leaving final exam can increase the motivation in students to learn scientific subjects, was not supported by students. Only the teachers thought it can have a real impact on the knowledge level of STEM.

Nevertheless, it is a promising result that the majority of students and teachers find science knowledge is important for the future. Even so, unfortunately, the popularity index of these subjects is still bad; this means that we have to find the reasons in the teaching-learning process. We need further improvement in educational policy. There are changes in Vocational Education and Training. There is a new law which support the mutual work of secondary vocational and technical higher education.

Authors think it is difficult to find the reasons and the best solutions in the teaching-learning process for improving effectiveness using natural sciences and STEM knowledge. In *International Journal of Engineering Pedagogy (iJEP)*, an open discussion has been started via messages of Guest Editors. We read these articles and tried to find that part of their messages that can help us to find the way to integrate STEM better in education. The first message is “Clearly structured learning paths facilitate a broad range of learning from theoretical knowledge to the development of application and metacognitive skills.” [8]. The second that is worth remembering is “...we do not know the future. But the only thing which is sure, is that in the future we must strive to master change.” [9].

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