



STUDENTS' ATTITUDE TOWARDS STEM EDUCATION

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Abstract: STEM is the acronym of Science, Technology, Engineering, and Mathematics fields. STEM education refers both to teaching and learning in the above-mentioned disciplines, but especially to teaching and learning a new discipline based on the integration of Science, Technology, Engineering, and Mathematics. The present survey aims to investigate the opinion of a sample of 110 respondents, students from Romanian universities, taking into account: a) their experience in STEM fields during high school studies; (b) the engineer's profession and the engineer's skills; c) the factors that influenced their option to study one of the STEM fields. The results show that the respondents have been interested in STEM fields since secondary and high school; this interest determined them to choose to continue their studies in a STEM field. Also, the majority of respondents agreed that the choice of their university specialisation was influenced by the teachers who taught them the subjects that they study at the university during their school years. The data also show that the students are convinced of the importance of the engineer's profession as well as of the engineering knowledge and skills.

Key words: STEM, education, survey, students, engineer.

1. Introduction

The National Research Council/CNC (2011) considers that Science, Technology, Engineering, and Mathematics (STEM) are "cultural achievements that reflect people's humanity, power the economy, and constitute fundamental aspects of our lives as citizens, workers, consumers, and parents". The progress of knowledge, skills and attitudes in STEM fields is essential for national security, economical growth, citizens health and the stability of the nations (Burke & Mattis, 2007, cited by Heaverlo, 2011).

Reviewing literature (CE, 2015) we find that "the umbrella term" STEM is frequently used for reference to: a) study disciplines, labour markets and occupations in the field of science, technology, engineering and mathematics (ibidem); b) training in individual STEM study disciplines; c) an interdisciplinary/multidisciplinary/transdisciplinary approach (English, 2016; Maden et al., 2013; Ostler, 2012; Spanias et al., 2016; White, 2014) "that integrates academics and real world concepts in schools, community and work based context" (Tsupros, in Ostler, 2015); d) a multidisciplinary and applied approach (White, 2014); e) learning of integrated STEM topics or school subjects based on a school curriculum developed in a transdisciplinary manner (English, 2016; Kearney, 2011); f) is an intentional, metadisciplinary approach to teaching and learning (Rider-Bertrand cited by Carmichael, 2017).

Other reasons why STEM education is a non traditional model of education are:

a) STEM model aims to radically change the way science is taught by introducing technology and engineering in students' activities, problems being solved by learning through discovery and through exploration activities (White, 2014).

b) the STEM model responds to students' development needs, it develops the students' critical and scientific thinking as well as an integrated perspective on science by familiarizing them with the methods designed to help them solve current real world problems (inquiry-based learning and cross-curricular work).

c) an efficient STEM model of teaching uses students' early experiences and interests, identifies and relies on pre-existing knowledge and abilities of students (what they know), involve them in experiences designed to sustain their interest for scientific knowledge and motivate them to take part in scientific activities (Capraro & Slough, 2013; CNC, 2011).

Development of STEM continues to be decisive for the development of the modern world. Creative innovation and technological progress are important elements for the improvement of the humans' quality of life and for the protection of the environment. Nonetheless, reports show that nowadays an insufficient number of students study STEM fields so as to cover the future needs of the society (Sjaastad, 2012; EC, 2015) and students' interest towards STEM learning is falling (Kelley & Knowles, 2016). As a result, many countries are trying to find measures in order to improve this situation (EC, 2015). The American education system, for example, is trying to increase the number of students who choose education and careers in STEM fields, to increase workforce in STEM fields and to develop STEM abilities of students, including of those who are not interested in studying STEM fields. A great attention is given to attracting women and minorities towards STEM education (CNC, 2011; EC, 2015).

STEM is an educational field of great importance and over time research was carried out in order to investigate: a) students' and youth's attitude towards STEM fields (Faber et al., 2013); b) students' motivation to choose a career in a STEM field (Wang, 2013); c) the sources (persons, environment, etc.) that influence students to pursue a STEM degree (Sjaastad, 2012); d) students' opinions regarding an engineering career (Capobianco et al., 2011); e) how girls can be motivated to follow a career in a STEM field (EC, 2015; Talley & Martinez Ortiz, 2017).

Thus, a study of Sjaastad on students enrolled in classes at Norwegian STEM profile universities shows that the majority of students were influenced by significant people with whom they have an interpersonal relationship (parents, brothers, sisters, relatives, teachers, acquaintances) and less by scientific personalities when choosing to follow a STEM career (Sjaastad, 2012). Wang's study (2013) was set to investigate the direct and indirect influence of exposure to mathematics and sciences during high school, accomplishments and motivational attributes regarding mathematics and initial experiences after entering a STEM field in college.

In Romania, although every important university centre has private or free tuition faculties which offer the possibility to study STEM fields, the number of students who study them is smaller than that of those who study the humanities.

For example, in the academic year 2013-2014 there were enrolled 433234 students in the higher education (Bachelor level) as it follows: technical education 27.6%; agricultural studies 3.4%; economy 18.5%; juridical studies 9.8%; medicine 13.1%; letters, sciences, mathematics, and informatics 25.5% and arts 1.8% (M.E.N.C.S., 2015). The quoted report mentions that the analysis of the distribution of students in terms of fields of study shows a gradual decrease of students enrolled in the legal and economic fields and the constant increase of the number of students enrolled in the technical, agricultural and medical fields. The percentage of students enrolled in higher education in fields as letters, sciences, mathematics, and informatics remain constant (ibidem).ext, please let the formatting given here.

2. Method

Research aims. The present study wants to answer the following research questions:

- a) Did the students who chose to study in a STEM field come from high schools where they studied sciences?
- b) What is the students' opinion towards an engineering career?
- c) Which STEM disciplines attracted respondents during the pre-university education related to the studies they attend at the university?
- d) Who (parents, teachers, acquaintances) had the greatest influence on the respondents' choice to study a STEM field in university?

Research methodology. A survey research was used as a methodological approach for this study, the approach being considered appropriate so as to collect information with regard to the research questions.

The instrument. The measurement tool used in this study was a modified version of the questionnaire Student Attitudes toward STEM Survey-Middle and High School Students (Faber et al., 2013) developed by the Friday Institute for Educational Innovation (2012). The survey contains four classes of questions regarding: students' attitude towards STEM education at pre-university level (A); students' attitude towards an engineering career (B); interest in different STEM fields (C); factors that influence the choice of a STEM career (D). The questionnaire was applied online using Google Forms and was addressed to students from the Faculty of Chemistry and Chemical Engineering from Babes-Bolyai University, Cluj-Napoca, with the request to share it with fellow students from other faculties and universities from Romania.

Participants. The participants in the study are students from faculties of chemistry, physics, biology, environment protection, mathematics, informatics, engineering, medicine, pharmacy and other related programs from different universities in Romania. 110 students from all three study levels (bachelor, master and PhD) answered the questionnaire. They took part in the study on a voluntary basis.

Data analysis. Responses to the first two sets of closed questions were given on a Likert scale with five response categories. The coding used was from 5 to 1, from 5 – strongly agree to 1 – strongly disagree, going through a neutral answer. For the third section of the questionnaire the answers were given on a Likert scale with four response categories where 1 – not interested and 4 – very interested. Thus, there was no neutral middle category in this case. For the last section of the questionnaire there were three possible answers: yes/no/I don't know.

The data was collected automatically and was processed by using Microsoft Excel. Data analysis was made by correlating different factors, such as high school's profile with the opinions and decisions regarding the chosen study field.

3. Results and Discussion

The questionnaire was completed by 110 students (74 female, 36 male) with ages between 19 and 30 years, of whom 17 are following doctoral studies, 66 bachelor studies and 27 master studies. The majority of respondents graduated from a high school where they studied mathematics-informatics or natural sciences, only 4% of them graduated from a high school with a specialisation in humanities. Moreover, the respondents have graduated from high schools across the country.

Section A of the questionnaire comprises four items regarding the respondents' opinion concerning mathematics in connection with their results at mathematics and sciences in pre-university education.

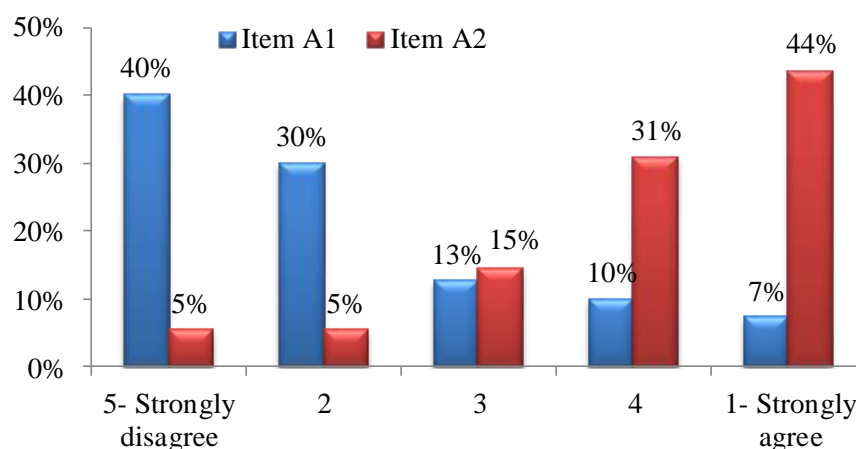


Figure 1. Students' answers to items A1: "Mathematics was a hard subject for me" and A2: "I was a student who was good at maths"

The majority of respondents strongly and partially disagree that mathematics was a hard subject for them (70%), on the contrary they agree that they were good at maths (75%). On the other hand, the majority of respondents (73%) say that they felt confident when approaching science topics (chemistry, physics, and biology); while 82% of respondents disagree that they were not good at sciences. The correlation is moderate to good for items A1 and A2 and acceptable for A3 and A4.

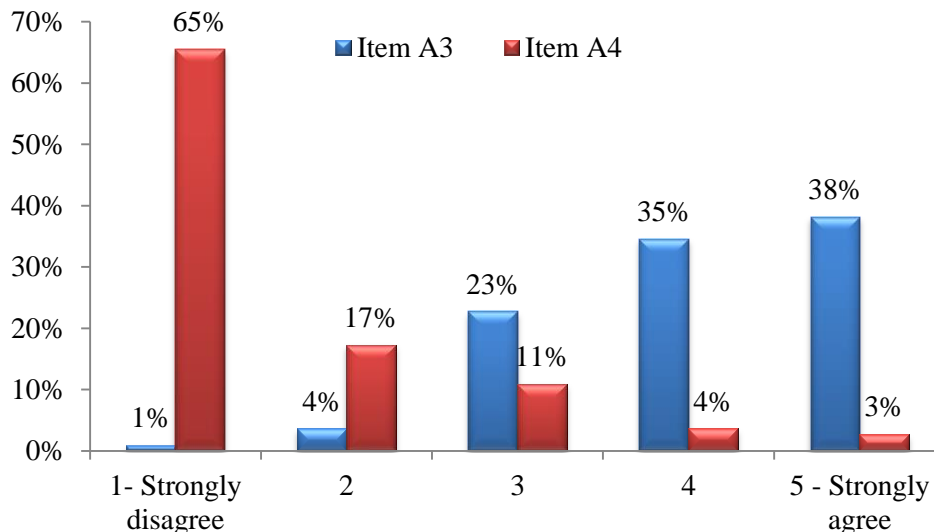


Figure 2. Students' answers to items A3: "I was confident when approaching science related topics (chemistry, physics, and biology)" and A4: "I was good at the majority of school subjects, but not at science subjects (chemistry, physics, and biology)"

Taking into consideration the answers from this section, we can consider that the vast majority of the respondents perceive mathematics and science as subjects they were good at in pre-university school, which would explain their choice to continue studying in a STEM field.

The purpose of section B of the questionnaire (see Table 1) was to identify the respondents' opinion regarding engineering and their technical personal abilities.

Table 1. The answers to the items in section B of the questionnaire

	1-strongly disagree	2	3	4	5-strongly agree
<i>Item B1.</i> "If I learn engineering, then I can improve things people use every day."	2.73%	4.55%	20.91%	31.82%	40.00%
<i>Item B2.</i> "I am good at building and fixing things."	2.73%	16.36%	19.09%	40.00%	21.82%
<i>Item B3.</i> "I would like to use creativity and innovation in my future work."	0.91%	3.64%	9.09%	31.82%	54.55%
<i>Item B4.</i> "Knowing how to use math and science together will allow me to invent useful things."	0.00%	10.00%	24.55%	35.45%	30.00%

Respondents consider that they possess the technical abilities required for building and fixing things (4.02 on average). The largest percentage of strong agreement was obtained for item B3 which was referring to creativity and innovation, therefore identifying the main attributes of an engineer (4.35 on average). Acceptable degrees of association are present between the answers to items B1, B3 and B4.

Section C of the questionnaire was dedicated to identification of students' interest in a STEM career (see Table 2). Results show that the majority of respondents are interested or very interested in the considered fields.

Table 2. Students' interest, while they were in high school, towards following a career in a STEM field

Field	Not at all interested	Not so interested	Interested	Very interested
<i>Item C1.</i> Physics	8%	25%	39%	28%
<i>Item C2.</i> Environment protection	8%	25%	41%	25%
<i>Item C3.</i> Biology and zoology	11%	26%	29%	34%
<i>Item C4.</i> Mathematics	16%	25%	28%	30%
<i>Item C5.</i> Medicine	8%	15%	29%	48%
<i>Item C6.</i> Computer sciences	11%	25%	27%	36%
<i>Item C7.</i> Chemistry	5%	15%	21%	59%
<i>Item C9.</i> Engineering	5%	22%	42%	31%

In addition, we have to mention that when the questionnaire was conducted, 25% of respondents were studying chemistry, 34% chemical engineering, 10% different engineering programs, 9% medicine or pharmacy, 9% informatics. The rest of the respondents were studying biology, physics, environment protection or interdisciplinary sciences.

Taking a closer look at the data, it can be observed that during high school 80% of the respondents were interested in following a career in chemistry, but at present only 67% of them declare that they study chemistry. Similarly, 73% of respondents were interested in following a career in engineering, but now only 44% of them study this field.

Next place in students' preferences was occupied by a career in medicine (77%), but at this point only 9% of respondents actually study in this field. This may be a consequence of the fact that the admission to Medicine is more difficult than for other faculties. Mostly, students rejected from Medicine choose to study chemistry or biology as the admission to Medicine tested their chemistry and biology knowledge.

Going further down the list, 73% of respondents said they were interested in following a career in computer science, but only 12% of them actually study this field.

Results show that the greatest degree of lack of interest was found for a job in mathematics (16%) although answers to item A2 showed that 45% of respondents considered that they were good at maths.

Section D of the questionnaire comprised three questions regarding the extrinsic motivation of the participants when choosing their study field, and implicitly the career they want to follow when they finish their studies (see Table 3).

Table 3. Extrinsic motivation of participants in choosing their study field

	Yes	No	I am not sure
<i>Item D1.</i> "Did you choose to study chemistry/physics/biology/mathematics/engineering because you know someone who works in this field?"	20.91%	72.73%	6.36%
<i>Item D2.</i> "Did you choose to study chemistry/physics/biology/mathematics/engineering because you liked your teacher in pre-university education?"	49.09%	50.91%	0.00%
<i>Item D3.</i> "Did you choose to study chemistry/physics/biology/mathematics/engineering because your parents advised you to?"	9.09%	90.91%	0.00%

Asked if they chose to follow a STEM career by dint of the people they know who work in this field, only 21% of the respondents said yes. The situation was very different when the participants were asked if they chose to study in a STEM field because they liked their teachers before coming to the university. Almost 50% of students responded affirmative, which shows that teachers have a big influence on students' choices regarding their future even long after they left school. Also, when asked if their parents guided/persuaded them to choose what to study, the vast majority of students (91%) gave a negative answer. As a result, regarding the participants in this study, we can conclude that parents were not a significant influence when it came to choosing their future career, but teachers had a significant contribution. Also, it is worth mentioning that a significant percentage (35%) of respondents answered negatively to all three items.

Discussion

The majority of respondents are female (67.27%). This result is in agreement with all the studies that show that in Romania there is no question about gender difference when it comes to STEM education.

After analysing the collected data it can be observed that 96% of respondents who chose to study a STEM field have graduated from a high school where they studied sciences intensively, which is equivalent to 6-11 hours/week of mathematics and sciences (chemistry, physics, and biology) with a more developed curriculum than that for humanities. Almost 70% of respondents perceived their experience with mathematics and science at high school level as a positive one. This is in agreement with the results presented by Wang (2013), which showed a correlation between the positive experiences with mathematics and science and the choice to study a STEM field.

Results show that the participants in the study have a positive view on an engineering career, which was highlighted by the fact that 44% of them study different types of engineering.

Regarding pre-university students' interest for different STEM careers, answers show that of great interest are chemistry (80%) and medicine (77%) and engineering (73%). When in high school, the vast majority of the respondents were very interested in following a career in chemistry, but only 67% of them declare that they study in this field. When it comes to medicine, though, the percentage of those who actually study in this field is five times smaller than that of those who were interested in following a career in medicine.

Finally, answers show that sciences or maths teachers from pre-university education have influenced students' option to study in a STEM field (49%). This is in agreement with Pedretti et al's opinion (2006), Faitar & Faitar (2013) and with results obtained by Sjaastad (2012), which showed that more than 40% of respondents were influenced in their choice of study field by the people with whom they had an interpersonal relationship (parents, teachers, acquaintances). Although in the previously mentioned study the greatest influence was exerted by parents, our results show that teachers are responsible for students' interest in studying a STEM field. This is probably owed to the way in which teachers knew how to make learning science and mathematics fun and interesting for the students.

The fact that more than a third of respondents answered negatively to all three items reveals the existence of other important factors that determine their choice of a field of studies.

The research limits are represented by the small number of respondents and by the fact that the majority of them (67.27%) come from the same place, which is the Faculty of Chemistry and Chemical Engineering.

4. Conclusion

The research results show that teachers are the most important factor when it comes to attracting young people into STEM fields. As a result, they should be trained regarding multi-, inter- and transdisciplinary approaches to STEM fields. English (2006) shows that such approaches include basic concepts and skills for one discipline as well as common concepts and skills for two or more disciplines. Such approaches represent the foundation of understanding the topics and of solving the problems and projects from the real world as well as the transfer of understanding and competence to new or unfamiliar situations, competence which is considered fundamental in today's society

(Committee on Integrated STEM Education 2014). Also, they facilitate education in engineering, another concern of education worldwide. (Government-University-Industry Research Roundtable et al. 2003).

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