Exploring students knowledge and interesting concerning STEM field

Doukakis Spyridon¹, Katsoulis Stylianos², Pylioti Ioanna³

¹ Mathematics and Computer Science Instructor, Pierce-The American College of Greece
² Technology & Computer Science Instructor, Pierce-The American College of Greece
³ Computer Science Instructor, Pierce-The American College of Greece

Summary
The present study presents the results of an empirical questionnaire survey conducted on a sample of 266 students of 8th grade. The survey was conducted before the start of an annual STEM program implemented as part of the curriculum with the involvement and participation of instructors of educational science, technology, computing and mathematics. According to the survey results, 47% of students declares that he knows what is the field that combines science, technology, engineering and mathematics. Moreover, the students give emphasis on teamwork 59%, while 1 in 2 denotes confident of his hers technical capabilities. Moreover, interesting results occur on their thoughts about studying in fields related to STEM. The results contribute to determining the approach of STEM programs so that students can reap maximum benefits.

Keywords: STEM, Empirical research to students, Studies

1. Introduction
The integration of STEM programs in primary and secondary education is one of the targets in many educational systems in various countries worldwide. The purpose of integration is to strengthen students to be able to meet the demands of a future workplace and in the wider society. The integration of the programs is highlighted by European Union and US institutions [1, 2] and is associated with both an increase in jobs requiring knowledge of STEM field, and with the understanding of the field itself in order to enhance the skills and decision making skills at individual and social levels. Similarly, in Australia is highlighted the need for action in the STEM field, as the involvement of trainees with relevant actions is vital to increase productivity [2].

The integration of relevant programs is important to be accompanied by research that will contribute to our understanding of how integration methods affect STEM curricula and identify possible deficiencies.

In this context, the present work initially attempts a brief literature review of recent actions integrating STEM studies in primary and secondary education. Then, the survey of 266 students of 8th grade and the results emerged are presented. The survey was carried out before the start of an annual STEM program incorporated in the curriculum of students of 8th grade, which is described briefly. The present work is completed by various findings that provide some ideas for further research.

2. Literature review
As mentioned above, European Union and US institutions conclude that STEM education can contribute to technical and scientific education and the wider training of the citizens of a modern society [1]. Although the term STEM refers to the transdisciplinary approach of science, technology, engineering and mathematics, in fact requires skills and knowledge from all fields, including Arts and
Entrepreneurship [3]. Moreover, it seems that STEM programs realized through pedagogical and didactic practices which are focused on active learning, interdisciplinary teaching approaches and the implementation of projects and students’ research [3].

More specifically, according to Wang et al. [4] the active participation of female and male students in STEM activities will result a significant proportion of students to choose a future career in related fields. Additionally, a significant increase in young women positively face the possibility of choosing a career in fields related to STEM, although traditionally they choose related professions in a lesser degree [5]. By contrast, students who have not attended STEM training programs do not show neither interest nor have the necessary skills to occupy such jobs [6]. Moreover, it appears that countries which integrate STEM activities in curricula are those that have high scores in the ranking of PISA competitions (South Korea, Japan, Finland, Germany) [2]. According to a recent survey of Wiswall et al. [7] the involvement of male and female students in STEM activities enhances their performance in mathematics and science tests in comparison with students who have not attended such activities. Similar results were obtained from a survey of Newman et al. [6], which shows that the students involved in STEM activities and belong to high risk groups or come from poor areas, improve their performance.

Considering all the above, the following paragraphs will briefly present a STEM program implemented within the curriculum and the participation of all students of 8th grade of the “Pierce-The American College of Greece” in the school year 2016-2017, as well as the research carried out to students before the start of the program, together with the results obtained.

3. STEM program

Pierce-The American College of Greece is an equal and legally equivalent private school to Greek public schools. Pierce following the Greek curriculum as set by the Ministry of Education while at the same time, adopting innovative educational practices. In the context of derogations as to the timetable of private schools a STEM course is being implemented for one hour a week in the curriculum of all students of 8th grade. The program was designed and is implemented by Pierce faculty members (natural sciences, computer science, technology and mathematics). The program aims to involve the students' actions in areas of STEM field. Through their involvement in actions the students will result in the creation of a structure, which requires knowledge and skills in the areas of STEM field.

In this work, the training program for female and male students in STEM field is described briefly, since the aim of the paper is to present the results of research carried out to students before the start of the course.

4. Description of the survey

The first phase of the survey, the results of which are presented in this study, conducted during the first week of the school year 2016-2017 and involved 266 students of 8th grade. The survey was conducted before the implementation of the STEM program and students weren’t given any information about the program.
For the implementation of this research, the positivism Paradigm was selected and a quantitative approach was used. Data collection was conducted by using questionnaires which were distributed between the students prior to the beginning the STEM teaching intervention program. For the needs of the present study, a questionnaire developed by the Illinois Valley Community College during a program funded by the NRC (USA) was used [8]. The questionnaire was translated from English to Greek. Sentences were translated independently from five different individuals (two bi-lingual translators and the authors of this study). A meeting followed and after discussion the final statements were shaped. Goal was to ensure semantic equality with the original questionnaire while keeping a language understood from Greek 8th graders. The translated questionnaire consists of 24 questions/statements out of which the first 16 try to focus on whether the participants agree/disagree with certain statements which are relevant to the STEM field, using a Likert scale. The next six questions/statements emphasize on the participants self perceived confidence and also use a Likert scale. The last two questions used for the collection of demographic data (section and gender). In order to present descriptive statistics negative answers were grouped together, (strongly disagree and disagree) in one column. The same was applied for the positive answers (agree and strongly agree), which resulted into a two scale solution.

The sample consisted of 8th grade (N=266, Ngirls=132, Nboys=134). For the data entry and statistical analysis, the Statistical Package for the Social Sciences (SPSS) was used. Descriptive statistics were used (frequency and range) to ensure accurate data entry. Missing values remained at extremely low levels. Only 38 answers were absent out of 5852 requested (0.65%). Despite the fact that missing value replacement is not necessary for levels under 5% [9], missing values were replaced using Missing Value Analysis (MVA) [10].

Following, mean, standard error and standard deviation were calculated for all variables. Also, frequencies were calculated and non parametric (Mann Whitney tests were conducted between the distributions of boys and girls) for all variables. In addition, a factor analysis was performed for the creation of new sub-scales. Principal component analysis was used as estimation of the new sub-scales. Internal validity was examined using the Cronbach Alpha. The level of significance was set to p=.05.

### 5. Results

As mentioned above, the sample consisted of 8th grades students (N=266, Ngirls=132, Nboys=134). At Table 1 mean, standard error and standard deviation are presented for each question respectively.

<table>
<thead>
<tr>
<th>Question</th>
<th>Mean</th>
<th>Standard Error</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I know what is the field that combines science, technology, engineering and mathematics</td>
<td>2.40</td>
<td>.053</td>
<td>.868</td>
</tr>
<tr>
<td>2. I know what people do in the field that combines science, technology, engineering and mathematics</td>
<td>2.39</td>
<td>.052</td>
<td>.855</td>
</tr>
<tr>
<td>3. I believe that generally I must be creative</td>
<td>2.69</td>
<td>.077</td>
<td>1.249</td>
</tr>
<tr>
<td>4. I believe that generally I must be able to work in teams</td>
<td>2.69</td>
<td>.073</td>
<td>1.187</td>
</tr>
<tr>
<td>5. I believe that generally I must be good at mathematics</td>
<td>2.67</td>
<td>.066</td>
<td>1.077</td>
</tr>
<tr>
<td>6. I believe that generally I must be good at sciences</td>
<td>2.58</td>
<td>.062</td>
<td>1.014</td>
</tr>
<tr>
<td>7. I feel confident about the technical skills I possess</td>
<td>2.50</td>
<td>.059</td>
<td>.957</td>
</tr>
</tbody>
</table>
8. I enjoy mathematics  
9. I enjoy science  
10. I enjoy thinking on which way different things operate  
11. I enjoy finding out how different things operate  
12. I have thought of studying science  
13. I have thought of studying computer science  
14. I have thought of studying engineering  
15. I have thought of studying mathematics  
16. My parents encourage me to study science, computer science, engineering or mathematics  
17. I can complete practical assignments on my own  
18. I can complete practical assignments as a member of a team.  
19. I understand science  
20. I can complete an experiment in science  
21. I understand mathematics  
22. I can complete mathematic calculations

<table>
<thead>
<tr>
<th>Questions</th>
<th>Agree</th>
<th>Disagree</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I know what is the field that combines science, technology, engineering and mathematics</td>
<td>47%</td>
<td>53%</td>
<td>100%</td>
</tr>
<tr>
<td>2. I know what people do in the field that combines science, technology, engineering and mathematics</td>
<td>45%</td>
<td>55%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 1. Descriptive statistics for the 22 questions/statements

Data analysis showed that 47% of the students state that they know what is the field that combines science, technology, engineering and mathematics, while 45% of the students state that they are aware of what the people who operate in the field that combines science, technology, engineering and mathematics do (Graphs 1 and 2).

However, one out of two students states that he/she does not know anything about the STEM field what so ever, even if they know the individual field of STEM.

About six out of ten students believe that generally they must: a) be creative, b) teamwork, c) be good in math, d) be good in sciences. Similarly, six out of ten students state they enjoy math and sciences. In addition, one every two students feels sure for the technical skills he/she possesses. The last statements indicate the incomplete technical skill development during the previous school years. Another point of interest is that 56% of the students state that they enjoy thinking about and finding out in which way things operate. Regarding the students future plans, one out of two students is interested in studies in the field of mathematics and sciences (Graphs 3 and 4).

Graphs 1 and 2. General knowledge about the STEM field.
However, the percentage drops to 45% for students which consider engineering as a future field of profession. This drop continues since only four out of ten students have considered computer science as a future profession. Finally, four out of ten students state that their parents encourage them to study any topic from the STEM field. The reader however, should be aware that the students had just completed the 7th grade. Students of that age, do not have obtained an in depth knowledge of mathematics and sciences yet.

Moreover, even if only half the students feel confident about their technical skills, the percentage grows higher for students which feel they can complete a practical assignment alone (75%) or as a member of a team (82%) (Graph 5).

Similarly, many where the students that felt confident they could complete an experiment in sciences (72%) or do mathematic calculations (77%).

No significant differences appeared to the distributions of the given answers between boys and girls for the first 18 questions. However, this changed for the last four questions. Regarding questions 19-22, the boys appeared more confident a) to understand sciences (M=3.93, SD=.995) than girls (M=3.69, SD=.958), b) being able to complete an experiment in sciences (M=4.13, SD=.889) than girls (M=3.71,
SD=1.049), c) to understand mathematics (M=4.26, SD=.909) than girls (M=3.94, SD=1.090) and finally d) to complete mathematic calculations (M=4.29, SD=.978) than girls (M=3.86, SD=1.002). Mann Whitney test led to rejection of null hypothesis for the last four questions, since it produced significant differences between boys and girls for questions 19 (Z=-2.291, sig.=.022), 20 (Z=-3.333, sig.=0.001), 21 (Z=-2.472, sig.=.013) and 22 (Z=-4.104, sig.=.000).

Tests for sampling adequacy (K.M.O.=.822) and sphericity (Bartlett’s chi-square=2996, sig.=.000) showed that a factor analysis was suitable for the given answers. The analysis separated the questions to four sub-categories. The first regards general knowledge over the STEM field (questions 1 and 2), the second personal opinions and beliefs about the STEM field (questions 3-11), the third future plan for academic course (questions 12-16) and finally the fourth factor, the level of confidence over activities relevant to the STEM field (questions 17-22). The combination of the previous four factors led to more than 65% of the variance explained. The factor analysis findings showed that there was no necessity for rotation.

An average value was calculated for each sub-category. According to the findings of the four sub-scales (knowledge, opinion, profession and confidence), a reliability analysis was conducted (Cronbach Alpha) to ensure internal validity.

The results are given to the following Table.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Cronbach Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Knowledge</td>
<td>.778</td>
</tr>
<tr>
<td>2. Opinion</td>
<td>.927</td>
</tr>
<tr>
<td>3. Profession</td>
<td>.697</td>
</tr>
<tr>
<td>4. Confidence</td>
<td>.750</td>
</tr>
</tbody>
</table>

Table 2. Internal validity test results

All sub-scales remained to above than good levels.

6. Discussion and conclusions

The empirical survey conducted on high school students of 8th grade, showed that further education is needed for them to be able to understand and explain the interdisciplinary field of STEM. This can be achieved either by including parallel activities within existing curricula or by integrating independent activities in the schools’ timetable. Moreover, creativity and collaboration seem absent from the beliefs of students and this is mainly due to the lack of related activities in the schools, although curricula have such references which ultimately are not realized in the classrooms as a result of multiple factors such as lack of time, the large number of students and poor infrastructure. Thus, such programs in secondary education should focus at the closing of the gap between formal and informal knowledge obtained according STEM programs. In addition, it is essential to strive towards such skill development and change of students’ beliefs, which are relevant to STEM programs. Relevant with the previous statement, is also the need of STEM approach to tertiary education and professional organizations. Moreover, it is important to focus to students’ self efficacy perception to successfully undergo such programs in order to improve their abilities skills.
Additionally, it is interesting that only 4 out of 10 students declare that they plan to study in the field of computer science. The conversion of such a perspective is important to be a main target of STEM programs both in Greece and in the rest of Europe, since EU evidence shows that there will be an increase of about 670,000 jobs offered in professions related to computer science and use of digital tools [11]. Bearing in mind that the relevant professions do not require the physical presence of the worker, is important to support and prepare male and female students to study in the field of digital technologies [11].

Concluding the discussion and the results of the survey, and as an epilogue to this report, it should be noted that since we recognize the value of integrating STEM activities in curricula of primary and secondary education, it is important to highlight and to answer the question of the need to develop a framework that provides favorable conditions to implement activities such as: the modification of curricula and the introduction of modern teaching practices, the training of teachers in the transdisciplinary STEM field, the creation of supporting structures and programs in higher education, new specialties of teachers, the cooperation with educational institutions and industrial enterprises and the creation of institutions that will aim at finding appropriate ways of integration and development activities in STEM education. Based on the above, the opportunity of building attractive and beneficial activities will be given for students, regardless their obligation of whether or not to participate in them.

Bibliography


