FOSTERING STEM EDUCATION CONSIDERING FEMALE PARTICIPATION GAP

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ABSTRACT

Despite the technological development, the digital era, and the fact that Science, Technology, Engineering and Mathematics (STEM) permeates all the modern world, the number of students choosing to pursue a career in STEM areas is very small in comparison to other careers. In particular, considering the gender, the gap increases even more. In this work, we present an industry-university program designed to stimulate STEM education and fostering the female interest and development in these areas. Considering our female undergrad students, the proposal was to engage them in the process, as the main agents. Our students prepared and gave lectures in schools about STEM areas. Together with some faculty members, they also developed and applied workshops based on hands-on and minds-on learning activities to spark young girls' curiosity in STEM areas. In all activities, it was performed an evaluation of learning outcomes, as STEM skills and interest. The program showed to be effective producing very positive remarks.

KEYWORDS

STEM, Education, Gender, Program, Student

1. INTRODUCTION

Science, Technology, Engineering and Mathematics (STEM) permeate everything nowadays. Innovations that emerge from these fields underpin much economic development leading to the establishment of creative enterprises, rewarding careers, and leading nations (Kanematsu and Barry, 2015). STEM workforce is essential to countries increase innovative capacity, meet economic needs and reach global competitiveness (Beede et al, 2011). The modern definition of STEM education includes the notion of integration by emphasizing logical and conceptual connections across different STEM fields, meaning that STEM is the purposeful integration of the various disciplines as used in solving real-world problems (Xie et al, 2015). For example, an engineer needs a well-developed understanding of the various science disciplines, math, and technology to support and provide context for their engineering designs and applications (Breiner et al, 2012). Moreover, STEM education is multi-faceted and goes beyond by supporting the developing of curiosity, inquisitiveness, critical-thinking, innovation and problem-solving capacities (Bruton, 2017).

It is important to introduce young children to the topics of STEM and to motivate as well as encourage them to pursue STEM subjects in every grade. Acting on a young age can have a lasting impact on learners, as it can set the stage for their later engagement and success in these fields (Gonzalez and Kuenzi, 2012; Bruton, 2017). By acquiring STEM concepts, students can perform better and be better prepared for advanced education or jobs in STEM fields (Ryan et al, 2011). Despite robust progress toward equity, one critical issue related to STEM education is the gap gender. Women are vastly underrepresented in STEM jobs and among STEM degree holders (Beede et al, 2011; Xie et al, 2015). Cultural beliefs introduce in women, during different stages of development, a bias perception about their competence to STEM. Other aspect that reduces women interest in STEM is the presence of stereotypically masculine objects in these fields (Correll, S.J., 2001; Christie, et al, 2017). An indicated answer to this issue is to increase young women's exposure to successful women in STEM careers, aiming to strengthen female students' self-identification with STEM and enhance their motivation to pursue STEM careers (Stout et al., 2011).

Based in the importance and demands of STEM education, as well as the discrepancies in female participation in STEM areas, we identify three main needs. The first one is to provide opportunities to explore concepts and engage in children problem-solving, while developing their knowledge and skills. The second need is to enable children to make informed choices about careers in STEM and related areas. The third need is an effort to increase participation of females in STEM areas. In this paper, we present a program established by a partnership between industry and university, whose objective is to incentive young students in STEM and to contribute to the increase in female participation in STEM. We describe the program actions and the associated results.

2. STEM EDUCATION PROGRAM

The demand of the program was presented by a company, concerned to the female gap in their position jobs. The initiative was part of a broader effort to accelerate the development of women leaders and to support women at all stages of their life to improve global health and well-being and drive sustainable economic growth. The team that conducted the program in 2017 was composed by six professors, one communication professor, and 34 undergrad students of a renowned Engineering Institute. All participants were women. The Institute accepted the challenge to propose and manage the program, since it would to contribute not only to society, but also to the development of its own undergrad students.

2.1 Actions

The program had mainly two actions, named lecture and workshop. Regarding lecture, our undergrad students were in charge to produce or identify materials, including presentations and videos. The lecture was divided in three topics. The first topic introduced STEM concepts and presented famous women in STEM. The second topic in lecture presented the female gap in STEM, using data about the number of male and female professionals in distinct countries, and about the economic benefit for nations that reach a balance between male and female workforce. The third topic in lecture present focus on opportunities and careers in STEM, where we present information of our Engineering Institute, including courses, laboratories, student projects, interchange opportunities, and life in campus. Lectures took place in middle and high schools of our country for both boys and girls. To include boys in lectures was natural due to the mixed configuration of the classes in visited schools. Moreover, to have boys in lectures was essential to take the opportunity to stimulate them in STEM too, but mainly to present them the importance and need of women in STEM. The fact of having our undergrad students as lecturers was also a benefit of the program, since they have a language more adequate to reach the young public, and they were in fact STEM female representatives assuring the possibility of women take STEM careers.

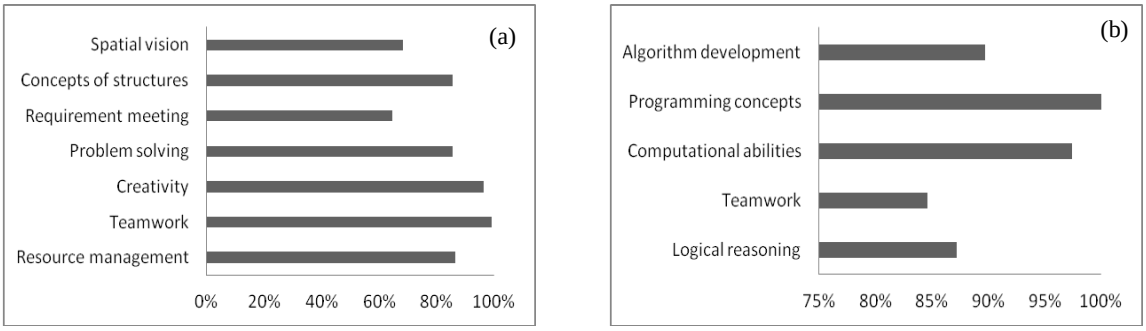

Figure 1. Percentage of students who declared to have acquired STEM skills in (a) “LEGO constructions” and (b) “Robotics with LEGO” workshops

Workshop was an initiative designed to spark girls’ curiosity in STEM areas through hands-on and minds-on learning activities. Workshops were conducted inside our institute facilities, in a way to bring girls to campus and make them be part of it. The public was only girls, in a way to attack directly the gender gap by stimulating girls in STEM education. At the first semester, we applied workshops already developed in

2016, including “LEGO constructions”, “Binary bracelets and logic gates”, “Robotics with LEGO”, “Game Programming”, “3D Printer”, and “Circuits with Circuit Scriber”. Our students developed new workshops for the second semester, but now focusing on low-cost activities, in order to make feasible both our expansion and reproduction of activities in other schools later. The eight new workshops, conducted during the second semester of 2017, as follows: “Mathplayground – learning Plane Geometry through Geoboards”, “Civil Engineering – playing with structures”, “Optics – propagation and emission of light”, “Spectrometer – characterization of light”, “Water rocket”, “Plastic plate activities for Math class”, “Acid/Base Science Experiment”, and “Introduction to Electronic and Programming using Arduino Uno”.

2.2 Results

Regarding the achievements of program actions, we had 40 lectures in seven distinct cities of our country mainly in the region of our institute. Together lectures reached 1,586 students, being 951 girls and 635 boys, between 10 and 19 years-old. For workshops, we received a total of 360 girls of middle schools (from 10 to 15 years old). In the first semester of 2017, each one of the 120 girls performed the six workshops available, characterizing an immersive program in STEM. In the second semester of 2017, 240 girls experienced only one workshop, due to an objective of expanding our initiatives to a larger public and increase program visibility.

We conducted initial evaluations regarding the gains in STEM education associated to workshops in the first semester of 2017, in a way to know how productive and assertive the proposed workshop was in developing STEM abilities and skills. For instance, Figure 1a shows the evaluation of “LEGO constructions” workshop with 110 respondents; and Figure 1b presents the evaluation of “Robotics with LEGO” workshop with 39 respondents. The evaluation of each workshop was made independently, in a sense of being more aligned to workshop subjects and objectives. It was an interesting assessment, but we decided to improve it by standardizing the evaluation questionnaire both to lectures and workshops in order to be able to compare outcomes of all actions and to analyze the overall program achievement.

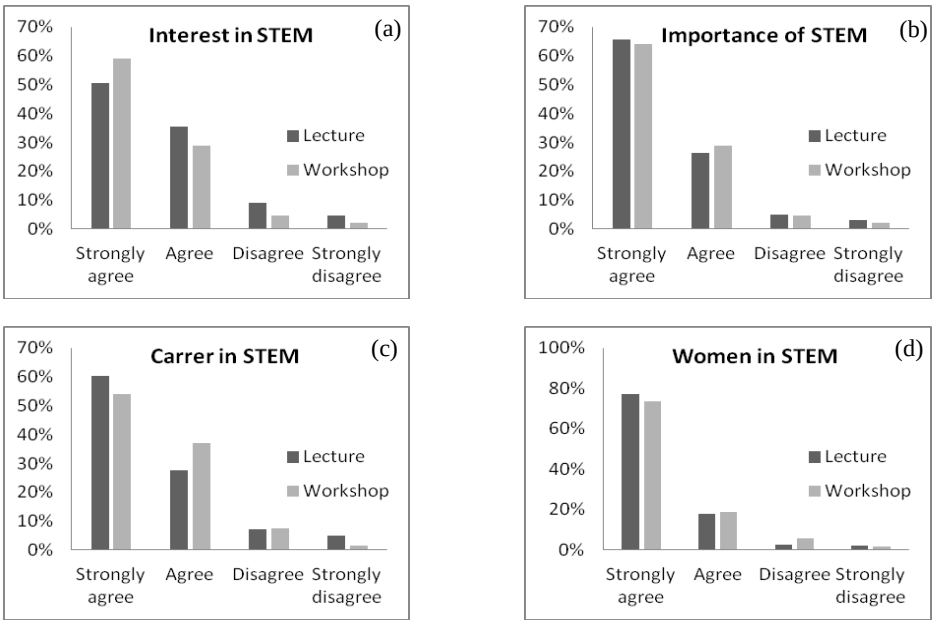

Figure 2. Evaluation of lectures and workshops considering: (a) perceived interest in STEM, (b) recognition of STEM importance, (c) knowledge of careers in STEM, and (d) understanding of women importance in STEM

Students that participated in lectures (during the year) and workshops (during the second semester of 2017) were invited to evaluate their experience after program actions considering the following perspectives: “The lecture/workshop contributed to increase my interest in STEM”, “After the lecture/workshop, I was able to understand the importance of STEM to society progress”, “After the lecture/workshop, I was able know

career option in STEM", "After the lecture/workshop, I understood the importance of women in STEM". As respondents, we had 211 girls that participate of a workshop, and 157 students (98 girls and 59 boys) that attended a lecture. The results are depicted in Figure 2. According to Figure 2a, lectures and workshops sparked the interest in STEM, but workshops were a little more effective. Figure 2b shows that lectures and workshops had similarly effect on presenting STEM relevance to society progress. According to Figure 2c, workshops promote interesting experiences that make girls identify possibilities of careers in STEM, whereas lectures could also present such possibilities based on examples of STEM projects and courses. Figure 2d shows that students comprehended the importance of women in STEM with interesting marks. For instance, considering 'strongly agree' and 'agree' together, lectures contributed to 95.09% and workshops to 92.5%, numbers superior to the other investigated perspectives.

3. CONCLUSION

We presented a program designed to stimulate STEM education together to contributing to female involvement in STEM arena. The program actions, lectures, and workshops have a fundamental difference regarding the period that the student is submitted to STEM concepts. A lecture was mainly an exposition, even interactions and questions were stimulated, where students acquired information during approximately one hour. Each workshop was designed to last three hours in a group of at most 30 girls, so they could receive more attention by the workshop conductors and take more time working with STEM concepts. Although this difference, according to the results of program evaluation, both lectures and workshops succeed in stimulating STEM education. Moreover, program actions supported the dissemination of the importance of women in STEM careers and promoted the involvement with STEM to young girls. The program exemplifies actions that can be structured to spark STEM education and support female inclusion in STEM. We argue that the problem that motivated this paper is in fact a great challenge, which can only be overcome with a set of complementary initiatives around the work. The presented program can contribute to inspire the definition of new other programs, as well as the improvements of existing ones.

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