Breaking down barriers: encouraging participation of underserved groups in STEM for the future

Rompiendo barreras: Fomentando la participación de grupos desfavorecidos en STEM para el futuro

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Keywords

STEM education; educational experiences; disadvantaged groups; sociocultural challenges; social impact; equal opportunities.

Abstract

This article focuses on a project carried out by the IEEE Computer Society Student Chapter at the Costa Rica Institute of Technology. The project was aimed to encourage the participation of underprivileged groups in STEM (Science, Technology, Engineering, and Mathematics) careers through workshops and educational activities. It was conducted in four schools with low economic growth, with a focus on the participation of women in the activities. The project successfully brought STEM education closer to these groups, providing them with opportunities and tools to explore these areas. The results obtained during the workshops reflected increased interest and understanding among the students regarding STEM career options. The article highlights the importance of this project in the context of Latin American countries, where the growth of STEM careers has been slow due to prejudices and sociocultural problems. Topics addressed in the article include the objectives, significance, and results of the activity, the definition of underprivileged groups, the challenges these groups face in choosing STEM careers, as well as the associated statistics. The article also includes post-project observations from the perspective of students, teachers, and volunteers, providing a more comprehensive view of the impacts and challenges faced.

Palabras clave

Educación STEM; experiencias educativas; grupos desfavorecidos; desafíos socioculturales; impacto social; igualdad de oportunidades.

Resumen

El presente artículo se centra en un proyecto realizado por parte del Capítulo Estudiantil de IEEE Computer, en el Instituto Tecnológico de Costa Rica. Este proyecto tuvo como objetivo incentivar la participación de grupos desfavorecidos en carreras STEM (Ciencia, Tecnología, Ingeniería y Matemáticas) a través de la realización de talleres y actividades educativas, se llevó a cabo en cuatro colegios con bajo crecimiento económico, priorizando la participación de mujeres en las actividades. El proyecto logró acercar la educación STEM a estos grupos, proporcionándoles oportunidades y herramientas para explorar estas áreas. Los resultados obtenidos durante los talleres reflejaron un mayor interés y comprensión por parte de los estudiantes en cuanto a las opciones de carreras STEM. El artículo destaca la importancia de este proyecto en el contexto de países latinoamericanos, donde el crecimiento de las carreras STEM ha sido lento debido a prejuicios y problemas socioculturales. Abordaremos temas tales como el objetivo, importancia y resultados de la actividad, la definición de grupo desfavorecido, la problemática de estos grupos alrededor de la elección de carreras STEM, así como las estadísticas asociadas a ello. También se incluyen observaciones post-proyecto desde la perspectiva de estudiantes, maestros y voluntarios, que brindan una visión más completa de los impactos y desafíos enfrentados.

Introduction

According to the World Health Organization's glossary of terms used for Health Impact Assessment (HIA), a disadvantaged group applies to groups of people who, due to factors beyond their control, do not have the same opportunities as other more fortunate groups in society [6]. For example, economic or social factors.

The inclusion of these disadvantaged groups in science, technology, engineering and mathematics (STEM) careers is important, as the growth and development of these areas of education has generated a clear impact on society and the economy, which is expected to remain and increase in the future.

Despite this, there are still barriers that impede the participation of these groups in STEM careers. According to T. Wang and L. Degol [2], several studies have shown that teachers, as well as family caregivers, promote the belief that boys outperform girls in courses such as mathematics, even when the grades of both genders are similar. Thanks to this, these figures of power promote the participation of boys in science and mathematics activities, as opposed to girls. Although this adult influence may be unintentional, girls are likely to grow up thinking that the field of study of science and mathematics is dominated by the male gender [2]. In accordance with the research conducted by [1], it is concluded that, despite the efforts of the Costa Rican government and universities during the period from 2000 to 2018, women continue to be underrepresented in STEM careers in Costa Rican universities.

Likewise, the lack of equal opportunities compromises the choice of STEM careers for secondary school students. Purchasing power and educational experiences are factors associated with the choice of university careers [3]. In Costa Rica, there is a social and technological gap that threatens the interest of the student population in STEM areas. According to the study conducted by [4], private education in Costa Rica involves students in better technological opportunities to develop knowledge in mathematics, programming, robotics, science, among other areas of study, in addition to better prepare students to apply successfully to the most prestigious universities in the country. Due to the lack of interaction and exposure to STEM fields in Costa Rican public education, in addition to the disparity in opportunities, students in public schools present more obstacles to study STEM careers [4].

Studies suggest that interest in STEM careers should be influenced from an early age [1], as students' understanding of STEM concepts can drive the learning process and sustain their interest throughout elementary, high school, and even college [5].

This is why this project is proposed, with the main objective of encouraging disadvantaged groups to participate in STEM careers. A series of workshops and educational events have been held, in which students from low-income schools have attended and participated, focusing on the participation of women in the activities. This document presents the methodology used in the project, the analysis of the results and the conclusions obtained.

Materials and methods

The project was organized in different stages: planning, design and implementation. These phases allowed a structured execution of the project to obtain better results. Each of these phases is described below.

First, a brainstorming discussion, goal setting and definition of the main objective were conducted as part of the project planning. From the beginning, the objective of promoting STEM areas among primary and secondary school students was established. Through brainstorming,

plans were analyzed such as moving to different educational centers to give workshops or conducting the workshops virtually, however, it was finally decided to invite the students to the central campus of the Instituto Tecnológico de Costa Rica.

This decision was made with the idea of being able to carry out not only the workshops, but also a series of tours through different spaces of the university to show the participants of the activity enclosures such as classrooms and labs of computer, plasma, industrial maintenance, among other areas of study. This would favor the increase of students' interest and curiosity about the different STEM fields.

Regarding the workshops to be given, it was proposed to present basic concepts on the use of Arduino, App Inventor, Visualino and Snap Circuits, since the teaching of these principles brings students closer to the STEM development environment. At the same time, several proposals of educational institutions were analyzed, to invite to participate in the activities. Institutions located in places with little economic development, social problems and few opportunities for growth in STEM careers were taken into consideration, giving importance to the participation of a large number of female students.

Secondly, a schedule of activities was designed and the content of the workshops was prepared. Once the topics to be taught in the workshops had been analyzed, the content was presented to the volunteers who would teach the courses through a training process. Likewise, the work calendar was organized, assigning dates for the activities and their respective schedules. It was agreed to have work spaces with breaks for meals and a tour of the campus. Similarly, material was designed to present the different topics to the students participating in the activities.

In the same way, the physical components to be used in the workshops were prepared. For this, it was necessary to make an inventory of the elements that were available at the moment. There were some Arduino Uno electronic boards, whose operation had to be checked. In addition, some other components to work in conjunction with Arduino, such as servomotors, electrical cables, LEDs, buttons and other similar elements were reviewed.

Once having the information about the functional components available for the workshops, it was decided to purchase more Arduino Uno boards in order to increase the capacity to teach a larger number of students. In the same way, the educational institutions selected in the planning stage were contacted in order to coordinate dates in which to carry out the activities.

The third and final step was the implementation of the activities with the participating students. Members of the different educational institutions were received, among them the Colegio Técnico Profesional de Orosi, the Colegio Técnico Profesional de Santa Lucía and the Colegio Iribó. Each of these visits were carried out on the dates previously planned with each of the institutions.

During the participants' stay, the following activities took place: a talk on STEM principles, an introductory workshop on block-based programming with App Inventor, a workshop on the principles of Arduino operation, a tour of the central campus of the Instituto Tecnológico de Costa Rica and plasma lab, a workshop on Snap Circuits, an introductory workshop on Arduino programming with Visualino and, finally, a small project competition with Arduino.

During the execution of the activities, a technique that combines teaching and putting into practice for the students was applied. During the first part of the workshops, the volunteers were expected to demonstrate the contents, and then to promote the application of the knowledge acquired to the participants by allowing the controlled use of the different tools of the workshops.

Results

It should be clarified that the participants came from three different institutions, mentioned above. Two of the institutions correspond to technical highschools, i.e., highschools in which a technical degree is obtained upon completion, while the third highschool consisted of a women's highschool with no specialized orientation.

Figure 1. IEEE TEC Student Branch volunteers and students from the Colegio Técnico Profesional de Orosi.

Several of the participants from technical schools were already oriented towards STEM careers, while the third school had no STEM orientation.

During the workshops it was observed that especially in the women's school, the technological bases and interests in these subjects were biased, so that students who did not participate in extracurricular activities before the workshop, followed a tendency of interest towards traditional careers.

Taking into account the questions and conversations held during the activity among students, volunteers and speakers, the following table was created, in which we can see that there is a strong orientation of students from technical schools towards STEM careers, while the women's school has a lower percentage of interest. Despite this, the project successfully managed to generate greater interest in these careers in all schools, clarifying doubts and even introducing options to the project participants.

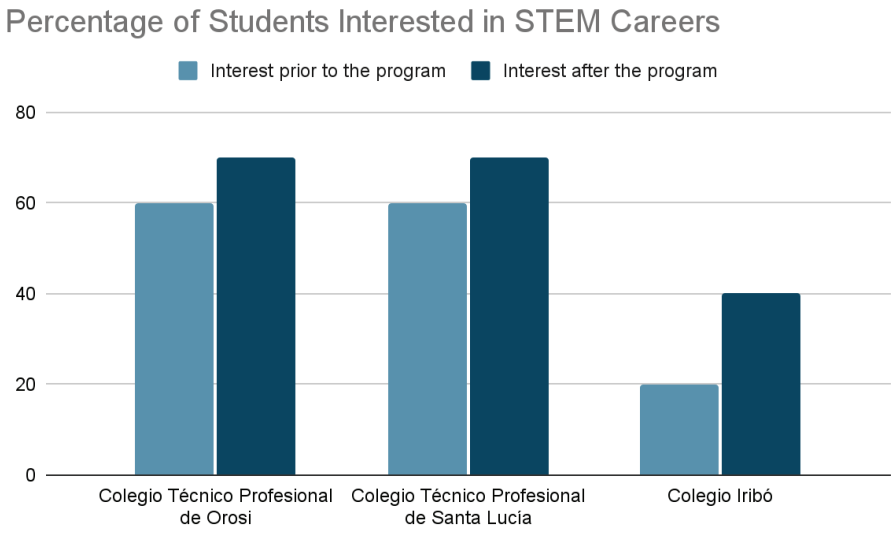

Figure 2. Student interest in STEM careers.

Additionally, we were able to observe a growth in the number of volunteers interested in participating in these workshops, indicating that there is greater involvement and commitment to increase knowledge and spaces for new generations of students to be involved in STEM activities.

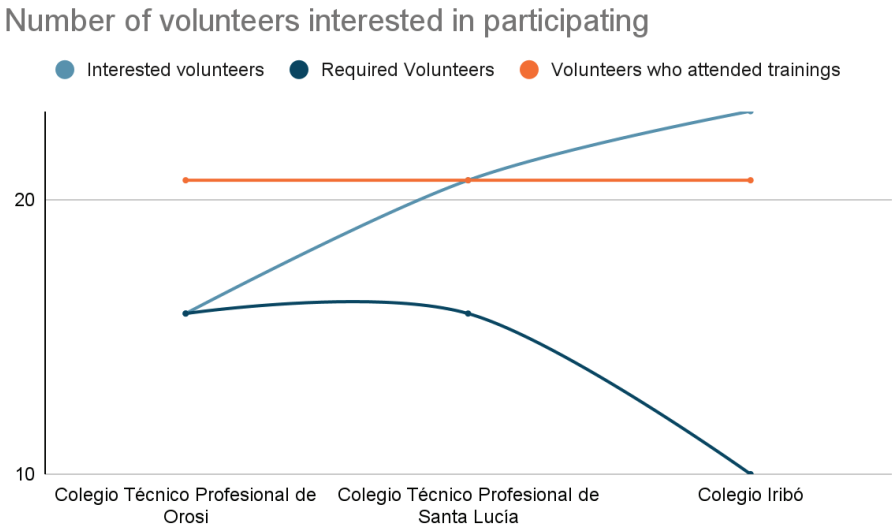

Figure 3. Interest of volunteers in participating in the workshops.

Conclusions

In summary, throughout the project, certain ways to promote STEM fields among high school students have been explored. Through the activities carried out, the main objective of the project was achieved from different working points.

First of all, the students acquired technical skills. The participants of the activities gained knowledge in basic Arduino programming, handling of basic Arduino components, block programming with App Inventor and handling of Snap Circuits components. These skills are valuable for the students' future academic and professional development.

In the same way, a space for teamwork and collaboration among the participants was created. Through the implementation of the knowledge acquired, students had the opportunity to work together with their peers in the creation of small projects using the different tools provided by the workshops. The importance of these collaborative work techniques is highlighted because they are essential in a work environment to promote creative and innovative thinking.

Participants were also given the opportunity to experience a real-world connection to STEM fields. Through lectures, workshops, and tours of laboratories in the different fields of study, students were able to get an up-close look at real-world applications of STEM skills. This generates a new perspective in the participants and motivates them about different STEM careers.

Figure 4. Students from the Colegio Iribó.

Along the same lines, a long-term impact on the students was generated. The project laid the groundwork for continuing to develop the skills and interest acquired in STEM throughout their professional careers. Furthermore, in addition to the collaborative work technique, students are expected to be able to apply this knowledge in their personal and professional lives.

Finally, the project succeeded in awakening the interest of participating students in STEM careers. Through the various workshops, lectures and tours of the Central Campus of the Instituto Tecnológico de Costa Rica, students increased their interest in the fields of science, mathematics, engineering, and technology.

We highly recommend other institutions, groups and organizations to replicate these kinds of activities. As commented before, it is of great importance to incentivize STEM careers for everyone, leaving behind the stigmas and stereotypes associated with them, and hopefully reducing the gap of underserved groups representation in these areas.

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Breaking Down Barriers: Encouraging participation of underserved groups in STEM for the future

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Introduction

Deprivation groups refer to individuals who do not have equal opportunities in STEM careers due to factors beyond their control, such as economic or social factors. The inclusion of disadvantaged groups in STEM careers is crucial, as the growth and development of these areas have a significant impact on society and the economy. However, barriers still hinder their participation in STEM careers. Teachers and family caregivers often promote the belief that boys outperform girls in courses, leading to girls being underrepresented in STEM careers.

Despite efforts by the Costa Rican government and universities, women continue to be underrepresented in STEM careers. The lack of equal opportunities in secondary school students and a social and technological gap threaten the interest of the student population in STEM areas.
Studies suggest that interest in STEM careers should be influenced from an early age, as students' understanding of STEM concepts can drive the learning process and sustain interest throughout elementary, high school, and college. This project aims to encourage disadvantaged groups to participate in STEM careers through workshops and educational events, focusing on the participation of women in STEM activities.

Materials and Methods

The project was organized in three stages: planning, design, and implementation. The main objective was to promote STEM areas among primary and secondary school students. The project involved brainstorming discussions, goal setting, and analyzing various options for workshops. The central campus of the Instituto Tecnológico de Costa Rica was chosen to host the workshops, which included tours of various university spaces. The workshops focused on basic concepts of electronic circuits and programming, bringing students closer to the STEM development environment. Educational institutions were also considered, considering areas with limited economic development, social problems, and opportunities for STEM careers.

The final step involved implementing the activities with participating students, including visits to the Colegio Técnico Profesional de Orosi, Colegio Técnico Profesional de Santa Lucía, and Colegio Iribó. During the participants' stay, various activities were held, including a talk on STEM principles, an introductory workshop on block-based programming with App Inventor, a tour of the central campus, a workshop on Snap Circuits, and an introductory workshop on Arduino operation.

Results and Discussion

Participants from three institutions attended workshops focusing on STEM careers. Two were technical highschools, while the third was a women's highschool without a specialized orientation. The workshops revealed a bias towards traditional careers in women's schools. The project generated greater interest in STEM careers, clarifying doubts and introducing options. The number of volunteers participating in the workshops grew, indicating greater commitment to increasing knowledge and opportunities for new generations of students.

Conclusions / Next Steps

The project aimed to promote STEM fields among high school students by acquiring technical skills in Arduino programming, teamwork, and collaboration. Participants gained knowledge in basic Arduino components, App Inventor, and Snap Circuits components, which are valuable for their academic and professional development. They also had the opportunity to experience real-world connections to STEM fields through lectures, workshops, and tours of laboratories.

This experience generated a new perspective and motivated them about different STEM careers. The project laid the groundwork for continuing to develop STEM skills and interest throughout their professional careers. It is crucial to incentivize STEM careers for everyone, reducing the gap of underserved groups representation in these areas.