Promoting innovation skills and social commitment through the University Social Project course in engineering students

Dr. Flor Angela Bravo, Pontificia Universidad Javeriana

Flor Angela Bravo has a bachelor's and a master's degree in electronic engineering engineer. She also has a doctoral degree in engineering. Flor Angela has experience in educational robotics, human-robot interaction, human-computer interaction, STEAM education, and intuitive programming.

Dr. Juan M Cruz, Rowan University

Juan M. Cruz is an assistant professor of Experiential Engineering Education at Rowan University. He has a Ph.D. in Engineering Education at Virginia Tech. a B.S. in Electronic Engineering and a Masters in Education from Universidad Javeriana in Colombia, His research interests include using system thinking to understand how instructional change occurs, faculty development process, and faculty and students' motivation.

Prof. Jairo Alberto Hurtado JAH, Pontificia Universidad Javeriana

Associate professor at Pontificia Universidad Javeriana Bogota, Colombia, at Electronics Department. He was Chair of Electronics Engineering Program and he has been working in different projects to get a better process learning in his students

Engagement in Practice: Promoting Innovation Skills and Social Commitment Through the University Social Project (PSU) Course in Engineering Students

Flor A. Bravo, Juan M. Cruz, and Jairo A. Hurtado
Engineering School, Pontificia Universidad Javeriana, Colombia.

Abstract

The purpose of this paper is to describe the development (i.e., rationale, methodology, validation and lessons learned) of a new line of action for community engagement projects with vulnerable populations in the electronic engineering (EE) major at Pontificia Universidad Javeriana University in Colombia. The rationale for this development is that the academic spaces for community service in the current curriculum are often limited to offering training or providing technical advice to some underserved communities in Bogota, Colombia. These academic spaces are part of a course called University Social Project (*Proyecto Social Universitario* - PSU). The current approach in PSU is insufficient to foster students' innovation skills, to help them understand the impact, commitment, and responsibility of their performance as an engineer in society, and to serve populations and institutions that are either underserved or in vulnerable conditions by providing solutions to their needs and problems**.** To enhance the educational experience of the PSU, we created a project model where PSU students conceive, design, and construct low-cost prototypes of educational technology (e.g., educational robots) to support the teaching and learning processes in educational institutions with low economic resources. The methodology to develop these projects is based on a *design thinking* approach. The prototypes developed were validated with end-users in real contexts. The main lessons learned were first, that the development of these projects gives students a great opportunity to see how their work as engineers can contribute to the solution of problems in our society; second, the need to associate PSU with another design course so that students invest more time working in the field; and third, the continuity of the project in other semesters allows having better versions of the prototype of the product so it could be left in the beneficiary schools.

Keywords

Educational Robotics, Design Thinking, Social Practice, community engagement

Introduction

The benefits of community engagement for the education of engineering students are widely known and described [1-3]. Typically, universities offer academic spaces for community service in the curriculum of certain programs. In the case of the Electronic Engineering (EE) major of the Pontificia Universidad Javeriana University in Colombia, there is a course called University Social Project (*Proyecto Social Universitario*, PSU). During more than 30 years of different iterations and changes, this course has promoted the commitment and responsibility of EE students with vulnerable populations and institutions that the university has built a partnership with [4]. Its goal is to generate in students an attitude of reflection and change through experiences where they can learn elements of the social reality of Colombia and apply their knowledge in activities that contribute to the transformation of the context in which they serve. PSU supports students' immersion in real-world service activities typically in suburbs of the Bogota where many underserved populations and institutions with low economic resources coexist. PSU also responds to the 2nd ABET outcome[5].

However, the activities of the students in PSU have been mainly limited to offering training or providing technical advice to the community. We believe that this approach has missed opportunities for learning. The literature discusses that by engaging with communities, we can foster students' innovation skills [6, 7], help students to understand the impact, commitment, and responsibility of their performance as an engineer in society [8, 9]. Moreover, we can serve populations and institutions that are either underserved or in vulnerable conditions by developing products or processes that provide solutions to their needs and problems [10, 11].

To enhance the educational experience of the PSU, we implemented a project model where PSU students conceive, design, and construct low-cost prototypes of educational technology (e.g., educational robots) to support the teaching and learning processes in educational institutions with low economic resources. The development of these product prototypes not only promotes social commitment but also fosters creativity and innovation skills in students. This paper focuses on describing this project model in the PSU course and how the development of product prototypes using design thinking promotes social commitment and the development of creativity and innovation skills. The paper is structured as follows: the first section shows a brief description of the PSU course and its lines of work. The following section details an introduction to the methodology used in the topic for the development of educational technology products. Then, we present an example of an educational robotics product developed by PSU students, by specific request of some teachers of schools in which PSU projects were already carried out, but concerning other subjects and, finally, in the last section we provide the lessons learned and future work.

PSU Description

The University Social Project (PSU) is a theoretical-practical senior year course that is mandatory for all undergraduate programs of the Engineering school at Pontificia Universidad Javeriana University. Its objective is to promote the commitment and responsibility of students with populations and institutions in a technical, social or economically underserved situation. This course offers students the opportunity of experiencing elements of the social reality of the country and apply their knowledge and skills to contribute to the solution of problems faced by vulnerable communities and institutions. Students in the PSU have 4 hours of fieldwork per week (60 hours of fieldwork in the semester) in a beneficiary institution supervised and guided by an interlocutor (a community leader, teacher, or administrator) of the beneficiary institution. They also have two hours during six weeks of classroom activities guided by the PSU professor. Class time allocates different workshops and meetings to learn and reflect on the relevance of the practice and the responsibility of serving others. At the end of the semester, students present their results both in writing and in a presentation to the beneficiary institution and the class.

In the specific case of the EE Program, students traditionally participated in two types of projects: technical support services and training. For example, students conduct adult training in computer administration, conduct educational workshops for children, provide technical assistance to schoolteachers to involve specific technology in the classroom, and perform preventive and corrective maintenance of equipment. In recent years, we have developed a new project model in which students conceive, design, and implement a prototype of a product that solves a problem faced by the beneficiary population. This project model follows a design thinking approach[12] for students to develop their low-cost prototypes of educational technology.

These new projects in the PSU focus on the development of educational technology products for low-income educational institutions. This implies that students have to distribute the time of the course for the design and development of the product prototype and perform field work. In the latter, students must interact with end users (that is, students and teachers at the beneficiary school) to design a product that meets their needs.

At the end of the course, students present a prototype, its documentation and a report detailing the design and validation of the prototype. Students receive guidance and supervision from the course teacher, one or more volunteer experts in prototype development, and a school teacher to conduct validations of the prototype with the end-users. The following section describes in detail such projects and the methodology used.

Developing Projects to Promote Innovation Skills and Social Commitment with Design Thinking

We selected Design thinking[12] as the methodology to guide the development of the prototypes because it encourages students to develop creative and innovative skills that are considered as essential skills in the 21st century. Design thinking also promotes in students the commitment and responsibility of their performance as an engineer in society. With this user-centered methodology for creative problem solving, students engage and collaborate with users (e.g., students and teachers of the beneficiary schools) to find solutions that fit their desires, needs or problems[12]. The design thinking process proposed by the Hasso-Plattner Institute of Design at Stanford[13] proposes five stages, which students follow as part of the learning activities in the classroom. These stages are empathize, define, ideate, prototype, and test (see Figure 1). The next section describes in detail such stages to develop educational technology products in the PSU.

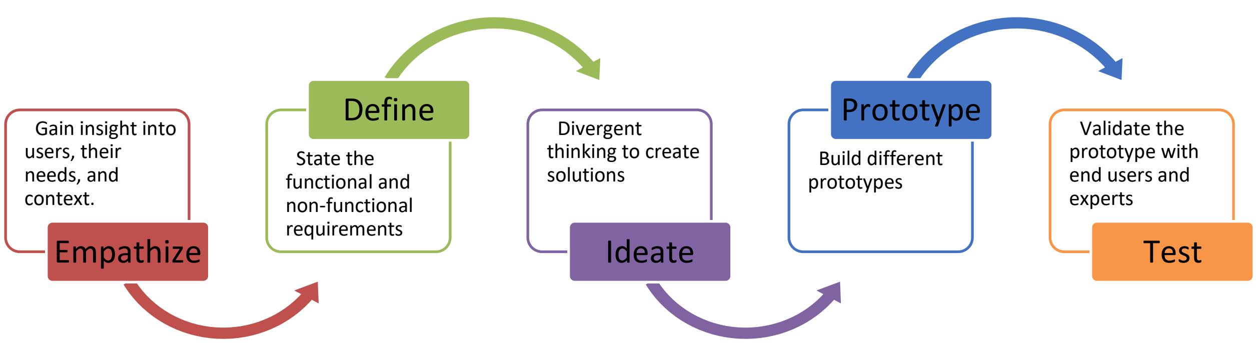

Figure 1 Design thinking stages based on [12]

Stage 1: Empathize. This first stage of the design thinking process allows students to have gained a real insight into users, their needs, and their context[12]. This stage starts by assigning students one or two advisors who are experts in educational technology. These advisors are volunteer professors or graduate students in the engineering school. The advisors ask the student a guiding question with a design challenge. An example of a guiding question is the following: as an engineer, how would you design an emotional robot to implement robotic storytelling activities with fifth grade students from low-income schools? According to the complexity of the design challenge, the professors assign the project to either only one student or a group of students.

Once the students receive the design challenge, they should interact with end-users to have a better understanding of the problems that they need to solve to complete the challenge. To achieve this objective, students conduct interviews, focus groups, observations, and a benchmarking process. They also consult subject matter experts and seek information related to the problem. Students receive a series of essential questions to guide their inquiry process and to foster their critical thinking (e.g., what features should the product have so that it can be used by users without experience in coding?). Likewise, these questions help students to reflect on the vulnerable populations´ problems and how they can use engineering to advance their solution. This stage ends with a meeting to discuss the findings of the inquiry process.

Stage 2: Define. In the define stage, students state the functional and non-functional requirements of their solution. Such solution is informed by the findings obtained in the empathize stage. Given the time constraints, students are given basic requirements of the solution. Students refine these requirements informed by the results of the previous stage. Then, they meet with the advisors to review and prioritize these requirements and create a report. In this meeting, advisors and students agree on the design requirements to implement in the prototype they will deliver at the end of the course. Students make an engineering report, which includes a work plan detailing the activities they will conduct in the project, the deliverables, and the delivery dates.

Stage 3: Ideate. In the ideate stage, students use divergent thinking to brainstorm possible solutions to the design challenge. Then, they use convergent thinking to analyze whether these ideas meet the design requirements identified in the previous stage. Students make an oral presentation of their ideas to receive comments from the advisors. At this stage, we promote skills such as creativity, innovation and communication in students.

Stage 4: Prototype. In the prototype stage, students build different prototypes of the selected solution. They use the first prototypes to validate whether the solution satisfactorily solves the design challenge or the end users like it. These first prototypes can be sketches or models. Once a solution to the design challenge is selected, students begin incrementally to develop a functional prototype of the product that can be used in the classroom. That is, they start implementing the design with some functionalities. After validating and refining the functionalities implemented, students add new functionalities to the prototype. This cycle repeats until the prototype includes all the desired functionalities. In the PSU, the electronics lab provides the materials (e.g., electronic components, craft materials) and equipment (e.g., 3D printers, laser cutting service) required for the construction of the prototype.

Stage 5: Test. In the test stage, students validate the prototypes with end users and experts. The process iterates between the stages of idea, prototype and test until they have a satisfactory solution to the design challenge. When a prototype that meets all the design requirements is ready, a pilot activity is conducted at a school for validation. Because a typical classroom generally has between 20 and 30 children, PSU students create enough versions of the designed prototype to facilitate a learning experience for work groups of 3 or 4 children. Students, professors and advisors meet to design a learning activity for the children using the developed educational technology prototype. They also define which evidence they will collect and the rubrics to evaluate both the learning experience and the prototype. Then, the students create an activity guide that includes the description and guidelines of the learning experience and other materials necessary for its implementation. The last deliverables for the PSU students are an oral presentation of the overall experience and a lab report describing the design process, the results of the validation tests, the lessons learned, the prototype, and the suggested improvements to the prototype.

Example of a PSU students project

In this section, we describe a project conducted with PSU students where they had to create a prototype of an emotional robot that supports the teaching and learning processes through robotic storytelling in the beneficiary institutions. This project arose from the need to promote technological educational innovations in low-income institutions. Most of these institutions do not have a budget to acquire commercial robotics platforms. Therefore, this project seeks to provide institutions with low-cost educational robots to bring students closer to technology and to promote active learning environments through robots. The robotic storytelling strategy was selected because it expands the use of robotics in the curriculum. That is, it is not limited to the class of technology, but can also be used in history, language, biology classes, among others.

To develop this project, they were advised by a teacher with expertise in educational robotics. In the empathize stage, students were asked to do an inquiry process to understand users, their needs and the design problem. Students answered guiding questions such as: how do teachers implement storytelling or dramatization activities in the classroom? And what are the design requirements so it can be useful to the beneficiary children and teachers? In the define stage, students stated the functional and non-functional requirements of the actor robot (e.g., the actor robot must be inexpensive, be able to reproduce audios, show emotions and be easily customizable). In the ideate stage, they generated ideas about the appearance, behavior, and control of the actor robot. In the prototype stage, students built prototypes of the robot actor and its interface. They conducted an activity with children to explore how the robot should move and what faces it should show to express happiness, sadness, anger, and surprise. Figures below show examples of the low-cost prototypes PSU students created to validate their ideas. Figure 1 shows a paper prototype and a mobile application to validate the emotional faces (*emojis*) of the actor robot. Figure 2 shows a cube with emotional faces to find out what kind of movements the robot actor should do to show certain emotions.

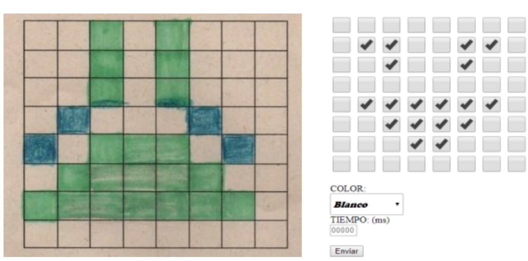

Figure 1 validating emotional faces of the actor robot

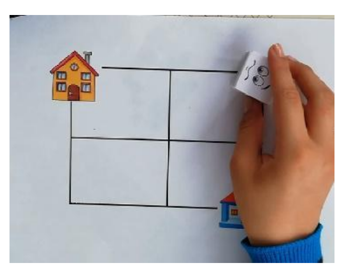

Figure 2 defining movements to in the robot actor to express emotions

Students make several iterations of the stages until they have a functional prototype of the actor robot and its control interface (see Figure 3). Then, they designed and implemented a learning experience in a class.

Figure 3 Final prototype of the expressive robot actor and its intuitive interface

Lessons learned and Future Work

One of the first limitations is the time allotted for developing the projects. For PSU students to have time to design and construct the prototype, we needed to reduce the fieldwork hours where students interact directly with the community. We understand the importance of such fieldwork, so students have more involvement with the community, more interaction with the end-users or even meet potential customers. In this way, they could create better designs and have better validation of the products. Hence, we are exploring the possibility of integrating these activities with another course for the development of these design projects.

We found that is unlikely that in an academic semester, students have a functional product robust enough to leave it at schools. Therefore, we grouped and prioritized the product requirements so the product can be developed incrementally. Each semester students are assigned a set of requirements to implement and validate. In this way, projects can be further developed and improved so they can be left at beneficiary schools. To achieve this continuity, it is essential that students document their work thoroughly. It is also important to clarify that, although new students did not develop the product from scratch, they had to conduct the entire design thinking process to add new features or improvements to the prototype.

We have developed three strategies to bring the developed products to the classroom. The first is the design of low cost and easily replicable products. The second is the development of educational material and training so that teachers can adopt these technological tools in their classes. The third strategy is to offer teacher support in using this technology in class. PSU Students make these strategies sustainable. For example, students whose line of work in PSU is training, would develop teaching materials, give workshops, and directly support teachers in class with this technology. Finally, the Pontificia Universidad Javeriana University has financed the development of several prototypes so students can conduct workshops and trainings in the beneficiary schools. We lend these product prototypes to schools during the academic semester. In the future, we will collaborate with the University's Innovation Department to create these products and sustain this technology in the beneficiary schools.

Finally, evaluation strategies are being studied to measure the learning or progress of school students, which involves the perspective of the teacher, such as that of the parents and the students themselves.

On the part of the students of the university, in their final presentation they have wonderful comments about their experience, but no other type of evaluation has yet been formalized about it, since the number of samples per semester would be very low.

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