

Methodology for Innovation in the Education of Future Engineers with Technological and Social Awareness

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Abstract— This paper presents a description of the methodology developed by the initiative *Jatun Kamachix*, which seeks to promote a technological and social consciousness within the educational process. The process involves a group of college students traveling to a remote location inside Peru and leading a series of workshops designed to promote scientific awareness, the development of innovation, research and technology in high school students. This methodology was applied in Yanahuanca, province of Peru, and the data presented in this paper was collected via observations performed during the duration of the workshops as well as questionnaires performed at the beginning and end of the total duration of the workshops.

Keywords—Innovation, Social Awareness, social responsibility, mechatronics.

I. INTRODUCTION

Out of the sources of knowledge, technology is an applied technique, derived from an analysis of different phenomena interpreted through a series of related patterns [1]. Concepts like innovation, technology and economic development are mentioned since 1942 in “Creative destruction” by Joseph Schumpeter [2]. From his work, it can be stated that the Human Development Index (HDI) for a country presents a direct relationship with regards to the level of investment in education, research and entrepreneurship that is carried out within it. Therefore, in recent years, developing countries are incorporating policies and programs that increase its HDI. In Latin America, Peru is one of the countries within the region that maintains an economy with an emerging market [3]. Until recent years, Peru HDI was one of the lowest in the region; however, in the last few years this situation is changing, the United Nations Development Program (UNDP) shows an HDI of 0.73. This indicator is a summary that analyses key dimensions of human development, mainly a long and healthy life, being knowledgeable and having a decent standard of living [4]. Likewise, the International Monetary Fund (IMF) project the favorable growth of the Gross National Product of 3.7%; this is a macroeconomic measurement that indicates the total dollar value of all goods and services produced over a specific time period [5]. While these indicators have increased considerably, this improvement is not reflected in the remote regions of the country due to a centralized system, the lack of integration programs and a noticeable gap in the educational standards [6]. One approach to raise the living standards lies in the fostering of a innovation in scientific and technological aware culture that links universities, schools and society to

create an integrated ecosystem able to understand the impact technology can have on society [7]. Scientific culture is understood as the dissemination of creativity, science and technology at every level of the society [8]. Challenges that require creative solutions areas of socioeconomic priority can be found in all levels of society; solutions to this challenges are financed through government institutions depending on the priorities established by the country [9]. Until recent years, the investment in research performed by the Peruvian government was scarce and unsustainable due to the lack of a developing ecosystem. In the present, organism like Concytec (National Council of Science, Technology and Technological Innovation) can be found which channel international and state funds to generate interdisciplinary research projects [10]. With the goal of adding to the currently forming ecosystem, constant technological advances and the creation of new educational methodologies around the world, Universities must take a more important role than just channeling knowledge [6]. In the year 2014, the new University Law considers the social responsibility as an important factor in academia, research and social development [11].

In relation to the context within Peru and with the goal of applying the presented methodology in various environments, the objective of this article is to show the relationship between science, technology and society under a methodological proposal designed and applied to act on the three central phases of knowledge development: school, university and society. The proposal links these phases by creating a series of workshops designed to provide sustainability and efficiency to the educational process. This method was employed and evaluated with the experience of project “*Jatun Kamachix: Talleres de ciencia y tecnología*” (Young leader: science and technology workshops). This project is an initiative by university students, who won the “Contest of interdisciplinary research with community outreach” organized by Pontifical Catholic University of Peru. The project took place between July 2014 and March 2015 in the town of Cerro de Pasco (Central sierra of Peru) and was orientated at 38 students in their 4th and 5th year of high school.

II. SOCIAL ENVIRONMENT OF THE PROJECT

A. About Pontifical Catholic University of Peru (PUCP)

The educational institution is located in the capital city of Peru and offers several careers from the faculties of Arts, Humanities, Sciences and Engineering. According to the QS

World University Rankings [12], in 2015 PUCP was ranked as the 21th best university in Latin America. These recognitions demonstrate that the design of the curricula and internal programs are able to provide comprehensive training to their student. The university also supports student initiatives by holding internal contests as well as offering technical and logistical support from their.

B. About Academic Direction of Social Responsibility (DARS) and the Faculty of Social Sciences

The DARS is an academic unit of the PUCP responsible for designing, promoting and implementing social responsibility initiatives within the University. Every year competitions are organized in which professors, students and administrative staff (in different categories), submit proposals for various projects based on social work with the support of different faculties. The competitions are prepared by The Faculty of Social Sciences in coordination with the DARS in order to provide support to initiatives that strengthen the ties between the society of Peru and the PUCP.

C. About the group of students developers of the initiative *Jatun Kamachix*.

The initiative was proposed and implemented by an interdisciplinary group of students. The group was formed with the motivation to develop a project to improve the conditions of their environment as well as their society. The proposal is based on the development of a joint program in which university students simultaneously improve their educational foundation and social awareness by engaging in a strategy of service learning in teaching high school students in remote locations of Peru with a series of workshops of science, technology and empathy. Service learning is an instructional technique that engages students in a community-based service activity in order to reinforce knowledge and skills learned in the classroom [13, 14]. The initiative was submitted and selected as a winner in its category in a contest of DARS and received counseling and subsequently a budget to execute the initiative of Research-Action. The participants of the initiative were mostly of an engineering background. This relationship can be seen in Fig 1.

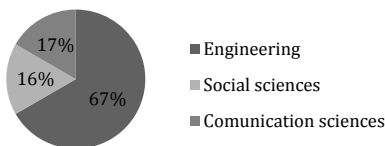


Fig 1. Careers of the students participating in the project.

D. About the knowledge previous to the population of work

The district of Yanahuanca where the workshops were executed. It is located in the province of Daniel Alcides Carrión (Department of Pasco) Fig 2. Its main economic activities are based on livestock, agriculture and mining on a smaller scale. It is one of towns with the highest ratio of students entering universities in the region. This however, has caused a decrease in its population due to the migration of

students in search of better opportunities. During the months of summer vacations, it is impossible to find young people in the town as they travel to the nearby city of Pasco to study. This migration of young people will in part cause a cultural lost within the community of Yanahuanca.

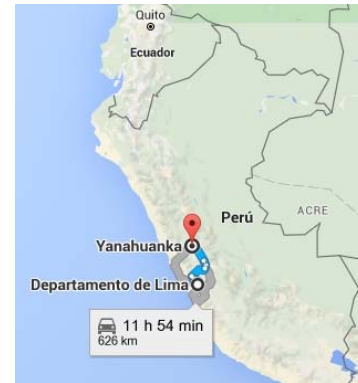


Fig 2. Location of the Yanahuanca district.

II. METHODOLOGY

The design of this methodology was developed throughout the course of the project with the goal to create a collaborative flow of knowledge. With university students: Bring them closer to the reality of multiple rural Peruvian communities, stimulate their creativity, create a link between them and their country as well as improve their social culture. With the high school students: Provide sources of information to a population that does not have access to it due to the centralization of knowledge within large cities in the country. Additionally, increase the interest in science and technology of high school students in rural regions. The development of this project suggests two independent and coordinated methodologies to achieve the objective.

A. Development with university students

The first is the introduction of university students into the community in order to recognize the value of investigation and technology regardless of their career. The challenge was to understand the problems presented and design basic solutions with recyclable material that the local high school students could make as a final project, as shown in Table I. In this first step, the recruitment of the students was done with an evaluation of their interests, career choice and future expectations. In the implementation step a total of six coaches, four of which were engineering majors, were part of the team.

a) Self-analysis:

Before developing the solution to make as a final project, a self-analysis of each participating university member was required in order to understand the strength and weaknesses of the group. Each university students shared about topics of their profession with the whole group, since one objective was to bring knowledge of each profession and its experiences through the university students. In addition it was expected that each student would be able to inspire people, so they also required a passion towards their corresponding careers. The university students would then be able to work together and

extend their knowledge to the local community in different ways depending on what they expect of their professions. In this way the self-analysis was performed as a way to externalize the knowledge learned in the classroom.

Table I. Methodology developed with university students

Self-analysis	The student reflects on his vocation.
Breaking paradigms	Recognized the value in investigation and technology regardless of them career.
listening and learning	Known the community and learn about its surroundings.
Workshop	Select two problems and design a ludic and basic solution.
Conscience of Research	Apply their knowledge in project management or thesis .

b) Breaking paradigms:

Many of the university students usually have paradigms that keep non-research, so at this stage break these paradigms to show them that the investigation is innate to the man. The experience, addressing appropriate and examples of your environment to meet the goal. Furthermore, workshops were developed in which each of the university students could share their pre-travel expectations about the community and the people they would meet. The goal of this activity was to attempt to break the generalizations about rural people and their way of life. Many of the participating university students had lived in the capital city and knew nothing of their own country, or about the way of life of said rural communities.

c) listening and learning:

Workshops on performs that would prepare the university students to develop empathy and listening skills [15]. This was required in order for the university students to be able to interact with the local high school students and research information on solutions to the issues presented on the community. During the preparation examples were considered in which the interdisciplinary nature of the work was an important factor since it extended the technical vision of the engineers, towards one more centered on the people.

d) Workshop:

After the initial experience with the local students, and the issues they presented, the participating university students were able to identify two basic problems. A brainstorming session was performed in order to raise proposals of basic workshops to explain and transmit basic principles to the local students that they could use to solve their community problems. This experience developed the creativity and synthesis of technical knowledge for the university students.

e) Conscience of research:

With the aim of making the project sustainable, it is needed to link the student towards research and projects related to social responsibility and technology within the university.

B. Development with the high school students

The second, in Table II, is the implementation of a workshop, designed to disseminate and increase the interest on

science and technology. This work was oriented for students and teachers of the local schools. The students were selected with the help of the local high school via an invitation taking into consideration a limit of 40 students. This limit was in accordance to the number of coaches available.

Table II. Methodology developed with high school students.

Strengthen ties	Create trust between students and helpers.
Analyze their surrounding	Recognized community problems with a self point of view.
Technology of change	Present tecnology with social impact examples.
Workshop	Select two problems and design a ludic, basic and eco-friendly solution.

a) Strengthen Ties:

The first step of our intervention was aimed at building an atmosphere of trust among students of the local high school and the university students. Since, we were outside of their immediate environment it was necessary to strengthen ties to develop the process of bilateral cooperation. A dynamic was developed with the aim of analyzing the characteristics of each participant and share personal information with either all the assistants or in small groups through means of artistic and oral expression. After this intervention it was observed that the shyness levels were higher in the students of the province in comparison with students of the capital city. the targets of this stage were reached on having increased the dynamics, nevertheless the shyness characteristics were supported for being society features.

b) Analyze their surrounding:

After meeting the participants and their interests, the following activities are used to know the community through the students by asking them to share their experiences. The local students are those who know better their community as well as issues that they consider to be a source of problems. The issues presented by the students are used as a starting point for determining how science and technology can be used. A dynamic was developed with the intention to get information about the community in addition to the opinions of the students, teachers and parents, with a task aimed at improving ties of generational communication (parents, grandparents and siblings). It was possible to observe that after speaking about their town and highlighting the potentialities and possible development opportunities, the adolescents proved to be proud of their origins and considered the area to have a high potential for tourism due to the quantity of archaeological remains found nearby along with the landscape beauty.

c) Technology of change:

Having obtained the opinions and factors considered to be issues by the local students, they were shown different ways in how those issues were tackled in other parts of the world. The issues presented were in large part about water and air pollution, problems in agriculture and other natural factor which were reduced with the use of science and technology. This helped the students to change their perception on Science and technology. They expanded their vision to contain the

development of technology in all disciplines such as medicine, architecture, art and engineering.

d) Workshop:

At the conclusion of the process of observation of the community a challenge was presented for the local students to think of a possible solution. The high schools were told to consider the problems presented, the solutions they had been shown as well as their own experience to employ the use of local and recyclable materials. In this stage the local students were able to use the presented information about solutions in other countries and adapted them to work inside their community with the help of the participating university students and their teachers.

III. RESULTS

In order to assess the high school students experience and perceptions we conducted pre- and post-workshop questionnaires that enabled us to determine the impact of our project on the students and participating teachers. We also conducted focus group interviews with the university students participating on the events to evaluate their own experience related to social awareness about their own culture and country after participating in a series of workshop studies with younger children in a rural community. The high school students who participated in the workshop were generally those who had interest in their studies and favored science related courses, and all of them had plans to continue their studies in a higher level institution. Their expressed reason for attending was a desire to learn about technology and how things work. Finding ways to improve their community and helping the environment were also main reason for their presence. Students responses to pre- and post-workshops questionnaires items on attitude towards technology were positive, many showing interest in how science, technology and engineering can work together with others to improve their community and city as well as help reduce the levels of contamination in the environment. A notable change was observed in their understanding of how science literacy can also help in areas and careers not directly related to it. For the perspective of the college students, many had volunteered to participate in order to help others and to gain a new perspective of their society; however many of them, having only lived in the capital before, did not know what to expect of the people nor the level of technology that was available to them. A few social stigmas caused by misinformation were also present in some of them. Focus groups were carried out in order for all college students participating in the event to understand how the experience can help enhance their student learning and social experience, as well as to get to know more about the chosen community. The pre-trip focus group conversation showed that the students showed that students had an understanding of technology and the role of engineering in society prior to the workshops, but some showed a lack of social awareness regarding the community. Once on the site, the misconceptions people had were gone and all participating members were able to experience and understand firsthand about the cultures within their own country. The post-trip focus group showed that while they were able to engage with the community members and students within the workshops, they noted the need for better preparation and involvement as well as more in depth

knowledge about the community before traveling in order to carry out similar projects in the future. However the changed point of view of the students regarding rural communities in their country proves that the experience was able to provide them with a higher understanding and social awareness about technology and the role of engineering.

IV. CONCLUSIONS AND FUTURE WORK

It is slightly frequent to find programs that link straight the society in its undergraduate curricula and of doing it is complex to find the sustainability and to maintain the interest in the student for these topics. Nevertheless, the possibility of the behavioral reinforcement does of the university an ideal place to form the social conscience. The student can link, propose and create if the space allows it to itself. The education based on challenges, publication of learning and centralization in targets improves the educational process and the experience of the student. The proposed methodology created an environment in which the university student of careers of engineering achievement explores its capacities as innovative agent in its society. The proposal is oriented in the collaborative work with the school because the university students have not yet completed its preparation and have greater empathy age with adolescents. The above mentioned it improves the effectiveness and the impact of the message. On the other hand, the college students are at a crucial stage in which the information they receive on science and technology may determine that they decide to study related careers as part of their educational process. In this way they contribute to close the ecosystem of training between the university, school and society. The referenced project is a first field test of the methodology that means that this is a work in progress that requires further testing to refine the social variables that may change the expected results. In addition, there are approaches to sustainability that must be verified with more time to know its effectiveness, as being temporary work interventions is necessary to have a space in the place that could support of knowledge for college students to and achieve the proposed objectives. In the case of university students is necessary to carry out a follow up more extensive to ensure the desired impacts. Therefore, the greatest amount of evidence of this methodology in more social contexts contributes to knowledge and to the improvement of the technique.

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