



Designing Humanitarian Engineering from Practice: Experiences and Outcomes in a Developing World Context.

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Engagement in Practice: Designing Humanitarian Engineering from Practice - Experiences and Outcomes in a Developing World Context

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Some universities and engineering schools around the world have developed programs and initiatives related with engineers making social and environmental impacts. This paper presents the results of a two years design process of a humanitarian engineering educational Program at Universidad Sergio Arboleda in Colombia in South America from a practical perspective. The Program looks for the generation of professionals more aware of their decisions where they change the perspective from “knowledge owners” to “design facilitators”. It is based in three main conceptual paths: Social Appropriation of Technology, Listening and co-creation, and facilitation of social business model for communities.

The main goal of this Program is to provide our engineering students with systemic thinking methodologies and skills, while been sensitive to a social context in order for them to be able to identify the main actors and variables of complex systems, and at the same contribute in the solution of complex problems. For the purpose of achieving this goal, the Program seeks to maximize the spaces of interactions between professors, students and communities to generate transversal knowledge between different disciplines and co-create solutions in a participatory way, teaching them how to work in a multidisciplinary context.

Introduction

In societies where there are issues of inequality, environmental deterioration, overpopulation, poor food security standards, amongst others, the university is called to play an active role, by training professionals with the skills and abilities required to respond to today's humanitarian challenges. Twenty first century engineers must embrace a new mission statement to contribute to building a more sustainable, stable, and equitable world. They must better meet the challenges of the developing world and address the needs of the most destitute people on our planet, balancing two goals: (i) effective sustainable community development, and (ii) meaningful education of engineers [1][2].

As a result, some universities and engineering schools around the world have developed programs and initiatives aimed at working with engineers with the purpose of undertaking social and environmental impact. Just to mention a few, the humanitarian engineering program at Colorado School of Mines wants its graduates to be able to reflect critically on the practices of engineering to know why, how, when and whether to use engineering in the co-creation of fair and sustainable solutions [3] or not. In Colombia, the initiative *Ingenieros Sin Fronteras* at Universidad de Los Andes is focused on educating engineers capable of proposing feasible, profitable, environmentally responsible, socially inclusive, innovative, technically possible, high-impact and sustainable solutions [4].

In line with these examples, this paper presents the proposal of the Humanitarian Engineering Educational Program in Universidad Sergio Arboleda in South America, as an innovative proposal in engineering education who's aim is for students to become professionals who can propose sustainable solutions to different problematics using systemic thinking. The use of systemic

thinking is aimed so that students have the capacity to design solutions considering a comprehensive number of stakeholders, variables and relations within a system [5].

To accomplish this objective, the following structure is proposed: (1) Describe the Value proposition of the Program (2) Detail the process of piloting and implementation of the Program, (3) Present an experience of community impact; and finally, (4) Conclude on the results obtained.

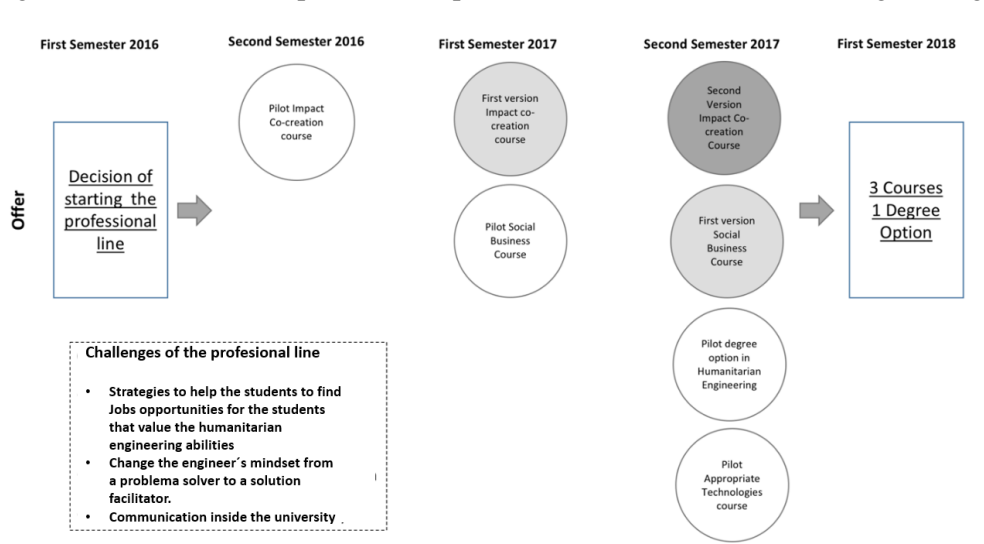
1. Universidad Sergio Arboleda context

The Industrial Engineering program of Universidad Sergio Arboleda, found the need of offering its students the possibility to developing capacities for designing engineering solutions that are closer to the social and environmental context in Colombia. This program was inspired by several engineering programs around the world that had developed initiatives related with engineers making social and environmental impacts, a new type of engineers, sensitive to social contexts, committed and qualified to serve communities by contributing to the solution of complex problems at a regional and national context, as the Humanitarian Engineering program from the Colorado School of Mines [6]. With this purpose in mind, the program is created as a professional line in humanitarian engineering which is defined as a package that any student can choose to take between one or two years before his graduation. Therefore, Industrial Engineering students, can decide to graduate with an emphasis on humanitarian engineering.

2. Timeline development of the professional line in Humanitarian Engineering

The design process of the professional line in humanitarian engineering began on the second semester of 2016. The next figure shows the steps followed in the past two years that result in the present value proposition (in 2018).

Figure 1: Timeline development of the professional line in humanitarian engineering



3. Results

After the previous experience, the Value Proposition for the professional line in humanitarian engineering was consolidated by 2018. This was a process in which the students played an important role, given that at end of the semester the students completed a survey where they were

asked about their perception about the course. The main priority was to understand if, from the standpoint of the students, there was a perception that the course was effectively adding value to their educational experience. The majority of the students considered that the courses offered content that was relevant in their training as engineers.

3.1. Value Proposition

Humanitarian engineering focuses on training professionals capable of creating impact solutions with communities in situations of economic, social or environmental vulnerability. Professionals in this field use systemic understanding for the resolution of social problems, and the design and evaluation of projects with social impact. They also recognize the changing nature of the environment and train to solve problems under real constraints in a specific context and with scarce resources. These professionals face the challenge of designing solutions for the basic needs of communities in situations of social, environmental or economic vulnerability.

All this is possible because of our will to create an engineering curriculum that will teach engineering students how to bring their systemic thinking knowledge and skills, as well as their cultural sensitivity, to bear on real-world problems, which means that it is aimed so that students can consider the stakeholders, variables and relations within a system. Some of the systemic methodologies and topics that contributed with this are Soft Systems Methodologies [7], Critic Heuristics [8], Idealized Design Methodologies [9], System Archetypes [10], and Systems Dynamics [11].

It is expected that in a working environment, a professional with the distinction of Humanitarian Engineering, will initiate the professional interest of: creating a social enterprise, managing or coordinating sustainability offices of large companies, being a consultant of social impact projects for multilateral organizations and international cooperation, and effectively performing in the public sector or civil society organizations.

3.2. Courses and Degree Option

After two years of the pilot program, the following value propositions were defined for each of the learning spaces. Such a structure is complemented to create the professional profile indicated in the previous section. Also, barriers and opportunities in implementing new initiatives for engineering problem solving were identified and taken into account [12]. These courses are available to all students in the University since negotiations between engineering and non-engineering perspectives are central in humanitarian engineering, because it allows to generate transversal knowledge between different disciplines and co-create solutions in a participatory way [13].

Table 2: Courses Professional Line - humanitarian engineering

Courses	Description
“Humanitarian Engineering 1”	<p><i>Impact Co-creation</i></p> <p>Experiential course where students take on a challenge of a community whose mission is, in interdisciplinary teams, to co-create a solution that responds to real needs with the assistance of a professor.</p> <p>Methodologies: Challenge-based Learning, U+lab and Po+CDIO</p>
	<i>Social Business</i>

“Humanitarian Engineering 2”	Practical course where students are trained as designers of social business models with a community-oriented approach. Methodologies: Social Lean CANVAS/ Prototyping and validation of sales from a social entrepreneurship.
“Humanitarian Engineering 3”	<i>Appropriate Technologies</i> This is a theoretical-practical course that reflects on the role of technology in relation to basic needs: water, hygiene, energy, food, communication and habitat. Methodologies: Analysis of case studies, low-cost technology construction workshops.
Degree Option	A Degree option where students take on the challenge of a community whose mission, in interdisciplinary teams, is to co-create a solution by assuming the role of facilitators, motivating real transformation within communities and supporting the decision-making processes.

Although each of the courses focuses on different contents and methodologies, all of them have the following principles that encourage and are based on the training of professionals with systemic thinking:

- Professionals as catalysts of co-creation processes do not bring a preconceived solution to the needs or problems of a community.
- By being in contact with the system's actors and making use of the available tools and resources, professionals can optimize the solution process from a sustainable and results-oriented perspective.
- The professional has a new perspective of what an organization is, by taking into account the roles of the actors, prioritizing the harmonious development of a project, through the articulation of interests to the fulfillment of a collective goal.
- The professional is perceived as part of the system being himself an active player in it.
- The professional is at the service of the organization or community and develops a solution from a divergent perspective regarding the problem to be addressed. He generates value with his proposals by defining possible scenarios, not adopting a paternalistic position, but acting as a facilitator.
- The professional's aim is to guarantee the appropriation of the solution process to ensure that it is successful and sustainable.

3.3.Experience: Community project - Quinoa production

Below is the experience developed during the piloting of the humanitarian engineering degree option, in order to show the possible scopes that are sought by the professional line in terms of community and learning impact.

- **Background:**

Cundinamarca is one of the largest departments of Colombia. Colombia's National Nutrition Situation Survey in 2010 revealed that nearly 19% of children in Cundinamarca suffer from some type of malnutrition [14]. The Government of Cundinamarca, with the purpose of seeking production alternatives that would tackle malnutrition and encourage economic diversity on a small and large scale, has set a goal of developing 1,500 hectares of ancestral crops, among which is the cultivation of quinoa [15].

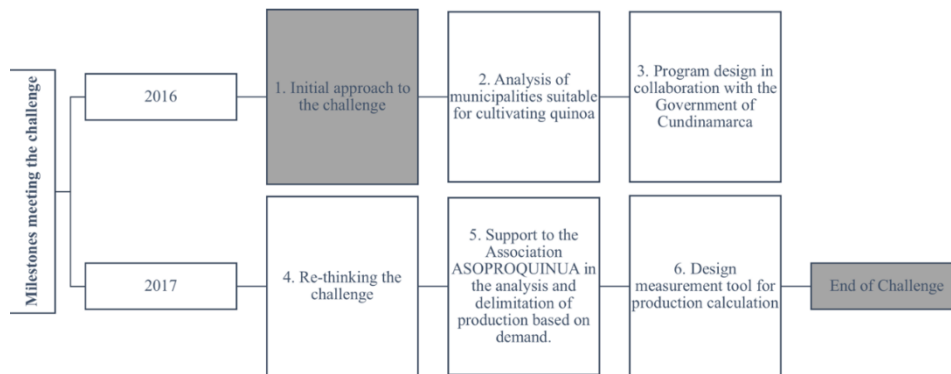
In order to address the previous situation, the Secretary of Agriculture of the Government of Cundinamarca, through the initiative "Regional Innovation Cluster", proposed the Universidad Sergio Arboleda to take on following challenge: How to promote the local production of quinoa in the department of Cundinamarca?

- **Meeting the challenge.**

The challenge posed by the Government of Cundinamarca, sought the possibility of creating a program that was aimed to promote the consumption and production of quinoa within the municipalities of the department.

On the basis of the previous challenge, 6 students from the industrial engineering program through the degree option in Humanitarian Engineering, generated proposals for solutions to a real need, that demonstrated a direct contribution from their role as students (Figure 2).

Figure 2: Pilot - Degree Option in humanitarian engineering



From the approach of the challenge, the students accompanied by a teacher, worked with the delegate of the Governorate of Cundinamarca that aimed to design a program to promote quinoa in the municipalities of the department. The proposal generated by the students was based on a needs analysis from the municipalities and their trajectory in the cultivation of quinoa. The students' input was very useful, and one of the main reasons taken into account for the delimitation of the municipalities in which quinoa production would be promoted. The municipality of Guasca-Cundinamarca was one of the identified places from which the association ASOPROQUINUA was selected as one of the beneficiaries of some production grants by the Government.

By 2017, the group of students focused their efforts on accompanying the ASOPROQUINUA association in the production process. Under this new scenario, the challenge was updated as follows: How much quinoa should ASOPROQUINUA produce? This new approach to the challenge was based on the lack of knowledge about standardization and good production practices within the group of associates. Currently (in 2018), the students are designing with the Association, tools to quantify production while accompanying it in the participation of the program proposed by the Government. Under this last dynamic, the students have learned how to plan a production process with incomplete information and other difficulties that the Association has, related to the lack of knowledge from an organizational and business perspective.

4. Conclusions

The Humanitarian engineering approach is a growing perspective in the academic context. In the case of Humanitarian Engineering Educational Program in Universidad Sergio Arboleda in South America, humanitarian engineering focuses on training professionals capable of creating impact solutions with communities in situations of economic, social or environmental vulnerability. The previous value proposition is the outcome of a design process of approximately two years, where, from the Program of Industrial Engineering, it was defined the need to promote an holistic perspective where in the design of solutions inside the context of social problems is not only relevant to focus on the technical or theoretical aspect of a solution, but it is essential to be aware of the problems encountered by the society. As part of this value proposition, a professional line in humanitarian engineering was designed and piloted with three courses: (1) Impact Co-creation, (2) Social Business and Appropriate Technologies, finishing with (3) Degree Option in humanitarian engineering. These courses and the degree option help the students to become professionals with systemic thinking.

This is an initiative that reflects an innovation in education. Students must get out from classrooms to interact with communities and apply their knowledge in the co-design of sustainable solutions. Also, students have an active participation in the design of the courses, so that the co-design that they trying to stablish with communities, is also replicated inside the university. All these factors contribute with the purpose of having a Program which is geared towards maximizing the interactions' spaces between professors, students and communities to generate transversal knowledge between different disciplines and to co-create solutions in a participatory way. It is expected that initiatives like this will be replicated in order to generate a change in engineering education around the world.

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