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Enhancing Global Social Resposibility through Multinational Collaborative Design Projects

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ABSTRACT

The new global order is requiring that engineers work in concurrent design teams geographically disperse around the world, and that they are designing products and systems which have a broader impact due to the free-trade agreements and globalization effects that are making the national boundaries disappear in the global market. Future engineers will be also challenged to find solutions to problems outside of their social, cultural and economical environment forcing them to make responsible decisions in different settings. Besides that, the rapid development of new technology is changing the society and the environment. The existing design solutions are satisfying immediate demands without considering future consequences. As a result, it is important to start educating students not only to be aware of the world with clear understanding of cross-cultural differences, but also with very high social responsibility and the ability to assess the local and global impact as well as the short and long term impact of their decisions during the design of products, systems and processes. This paper describes the approach used in the freshman Introduction to Engineering Design course to enhance global social responsibility through a collaborative design project carried out in collaboration with students in Latin America.

Keywords: Social responsibility, ethics, engienering education, multinational projects.

RESUMEN

El nuevo orden global está requiriendo que los ingenieros trabajen en equipos de diseño concurrente dispersos alrededor del mundo, y que ellos diseñen productos y sistemas los cuales tienen un impacto más amplio debido a los tratados de libre comercio y los efectos de la globalización que están haciendo que las fronteras nacionales desaparezcan en el mercado global. Los futuros ingenieros serán retados también a encontrar soluciones a los problemas por fuera de su ambiente social, cultural y económico forzándolos a tomar decisiones responsables en diferentes escenarios. Además de eso, el rápido desarrollo de nueva tecnología está cambiando a la sociedad y el medio ambiente. Las soluciones de diseño existentes están satisfaciendo demandas inmediatas sin considerar futuras consecuencias. Como resultado, es importante empezar a educar estudiantes no solamente que estén consientes del mundo con un entendimiento claro de las diferencias culturales, sino también con alta responsabilidad social y la habilidad para evaluar el impacto local y global así como el impacto a corto y largo tiempo de las decisiones durante el diseño de productos, sistemas y procesos. Este articulo describe el método usado en el curso de primer año Introducción al Diseño de Ingeniería para mejorar la responsabilidad social a través de proyectos de diseño colaborativo llevados a cabo en colaboración con estudiantes de latino América.

Palabras claves: Responsabilidad social, ética, educación de ingeniería, proyectos multinacionales.

1. INTRODUCTION

The development of new technology is changing the world at a very fast pace. New products and services and the need of establishing an infrastucture to support economic growth have ascertained a close relation between thechnoly development and social responsibility. This relation becomes more complex and challenging when the social responsibility is expanded beyond national borders. According to Lappalainen (2011), developed countries participated in the economic development of under-developed nations motivated by ideologies of modernisation and urbanisation but local voices expressed their concerns about technology development and its impact in the environment and the social life of the local communities. As a result, technology development should follow a sustainable development model that guarantess a healthy environment, economic growth and social welfare.

From the pure business perspective, Prasad (2008) states that international business and global ethics are not exclusive concepts. In fact, some authors (Amba-Rao, 1993; Bennett, 2002; McClintock, 1999) consider that multinational enterprises have the potential to bring social benefits to deprived communities particularly in the Third-World. However, there is a tendency to obliterate the voice of the conscious corporations (Spivak, 1988) by the Western capitalism. This tendency has to be reversed by aligning international businesses and a system of global ethics (Prasad, 2002). This can be achieved by preparing future professionals with the necessary knowledge, skills and social responsibility to succeed in the global workforce.

In the particular case of engineers, it is clear that they are responsible for technology development as they are challenged to design more and more new products and systems for the globla market. Furhtermore, they are part of a global community where they need to interact in teams, and collaborative networks. Therefore, new engineers are required not only to have a solid technical foundation in engineering but also a set of professionl skills in order to succesfully integrate technical knowledge, critical thinking, sensibility, and professional conduct to satisfy business interests and social benefits (Emilson and Lilje, 2008). The work presented here focuses on the global social resposibility aptitude required by the future world-class engineers and how to incorporate it in the engineering curriculum. This article describes a learning approach including a multinational collaborative design project used in the freshman course introduction to engineering design to foster global ethics, social responsibility and sustainable designs.

2. Engineering and Global Social Responsibility

According to Ju (2009), there is an endless cycle of innovation that brings new discoveries that urge new technologies, causing that emerging technologies take more and more control of the environment and human life. As a result, technology development is changing the world rapidly and in many instances, there is not enough time to reflect about the impact of a new product on the planet. This is because the corporate world is pressuring engineers for new products that will bring economic benefit to the society. In many cases, this economic benefit is for small portion of the society and the mid and long term consequences of new products could be devastating and have a global impact in the environment and the welfare of the planet.

A provocative issue for discussion is related to the responsibility of engineers in accelerating or decelerating the rapid growth of technology. The big corporations are in favor of keeping the fast pace of innovation and new discoveries, and in transforming those discoveries into new products or commodities that bring immediate economic return. On the other hand, there is a group of people in favor of having a regulated pace of innovation so engineers have time to properly assess the impact of new discoveries on the planet. To better understand this issue, Ju (2009) reported two different perspective of the relation between technology and society. The first perspective, considered the old perspective, is known as technological determinism. This perspective claims that technological evolution is a fundamental energy to change human society. The other perspective is known as social determinism. This perspective argues that society takes control of the progress of technology. In this case, the society plans and allocates resources for technology advancement. Ju (2009) argues that social determinism is a more suitable perspective since considers that technology is inside the society. This means that the technology is subordinated to the society. This is reflected in how different societies adopt, adapt, and develop new technology based on historical and cultural differences. This is a very important argument especially when we are considering the global dimension of the advancement of technology and the development of new products and systems.

It is evident that there is a close relation between technology development and society evolution. Different cultures are being affected and transformed due to technology developments despite the arguments presented in the previous paragraph regarding social determinism. It is arguable that even though different societies adopt and adapt technologies at their own pace, those societies are being transformed by adopting external technologies and changing their traditional behaviors. However, it is also true that not always new technologies are transferable directly or at a fast pace. Some societies resist the change in many cases due to cultural values. This represents an obstacle for the global corporations interested in controlling the global market and a challenge for engineers who are pressured to develop products to conquer new markets. This has generated a new approach for the development of products where the process of globalizing the design occurs first and then the process of localizing (making the product useful and attractive to local users) occurs later. This creates a dynamic in the relation technology-society that future engineers should be aware of.

The technology development and global social responsibility relation might take place at different levels or situations but it is important to stress that is always present. It could happen when developing countries assist under-developed nations to solve local challenges and grow their economies, or when the corporate world tries to reach new markets by developing new products and systems appealing to a broader population. Independent of the origin of this relation, engineers, as generators of new technology, must exercise social responsibility when they solve engineering challenges. In this context, global social responsibility means that engineers must be sensitive toward social and environmental issues, protect all living species, respect cultural differences, act ethically, recognize economic implications of decisions, and promote sustainability when advancing technology and developing new products and systems.

3. FOSTERING GLOBAL SOCIAL RESPONSIBILITY IN THE ENGINEERING CURRICULUM

There is a general consensus that the paradigms of engineering education must be changed and the future engineer must be prepared with a set of professional skills that complement the technical knowledge of the field. Of particular interest of this article is the idea of educating engineering students with the knowledge and attitude for global social responsibility when they exercise their career. Zandvoort (2009) in his work entitled "Preparing engineers for social responsibility" provides a summary of the work done by many researchers in the field. His synthesis of different works permits to realize that researchers have identified two main needs for educating social responsible engineers: the need of providing insight and solid knowledge of organizational, social, legal and political context; and the need of complementing knowledge and skills with motivation to facilitate a positive attitude toward social responsibility (Zandvoort, 2009).

Using the two needs explained above as starting point, this work triggered the following questions:

1. How global social responsibility could be introduced in the engineering curriculum?

2. Are ethics and sociology courses added as general education courses to the engineering curriculum sufficient to prepare social responsible engineers?

3. How can be effectively connected the knowledge and attitude with the practice of social responsible engineering?

4. How can the scope of social responsibility be effectively broadened to a global dimension?

Searching for answers to these questions, it is suggested that the education of global social responsible engineers should be holistic, longitudinal across the curriculum, multidisciplinary in scope, and well balanced between theoretical knowledge and practical application. The holistic approach means that students should understand the different dimensions (social, legal, cultural, ethical, psychological, economical, practical and environmental) of social responsibility, and how they are related and how they interact to form students' criterion. The process should be longitudinal starting in the first semester and should be cultivated across the curriculum. This means that is not a matter of one or two courses during the career but a matter of a set of courses and activities that permits to mature this skill. It should be a multidisciplinary approach so students study the different dimensions from different disciplines. This provides a diverse set of knowledge and experience to enrich global social responsibility. Finally, the learning experience should be a combination of fundamental theoretical concepts and engineering practice. Exposing the student to real situations will not only provide the opportunity to start exercising what they learn in the classroom but also serve as a motivational tool. Taking the students out of their comfort zone and confronting them with real tough situations around the world make them more receptive and sensible to social issues. Humanitarian engineering and engineering without borders (EWB) are two examples of initiatives that have been developed and are becoming very popular in the US and Europe as a means not only to serve deprived communities but also as a means to offer engineering students opportunities to practice their majors and to cultivate social responsibility in a global scenario. With the same purpose but at a local level, service learning projects are used in engineering in the US to serve the needs of local communities.

As described above, introducing social responsibility in engineering curriculum is not a matter of just an ethics, sociology or humanities course. This is a longitudinal effort compose of courses and experiences where students can first acclimate in the subject and then they can develop the competency until reach the proficiency stage that is usually attained at the professional level. As reported by Alexander et.al. (1995), learning take place at different stages and it is a process of building the knowledge over previous knowledge. Therefore, in the first stage of knowledge development, known as acclimatization, cognitive efforts are directed to build a framework of knowledge that prepare students for further learning. Usually at this stage, the interest in the subject is low and more effort is placed in just getting the work done. However, motivational or affective factors play a fundamental role in human learning, so increasing the exposure of the topic to students increase their interest in the subject causing that students get motivated in learning, and move their knowledge toward the competency stage (Alexander, 1995).

Based on the ideas suggested by Alexander's Model of Domain Learning (MDL), it is suggested that global social responsibility should be cultivated from the freshman year and increase exposure to the topic as students move forward in the engineering studies. One important goal during the freshman year is start the acclimation stage and promote the interest in the subject. A generic model for a typical engineering curriculum is depicted in Fig. 1. In this figure it can be seen that the theoretical knowledge is supported with practical applications along the curriculum. It is expected that interest in the subject will increase as the exposure to the topic and the connection with the engineering field increase. It is important to highlight here that the proposed projects during first year must expose the students to engineering problems where they are challenged to exercise global social responsibility at a basic level.

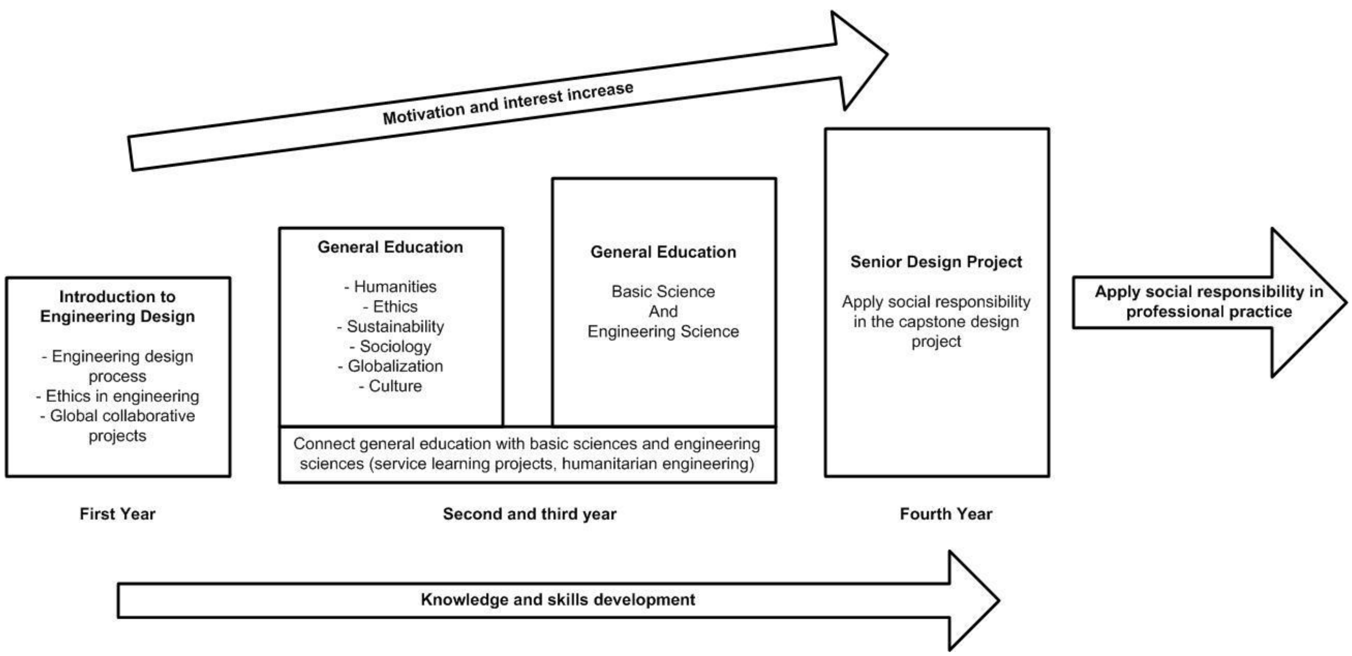

Figure 1: Generic model for engineering curriculum

This paper describes the material and the multinational collaborative project that have been introduced in the first year engineering design course to foster global social responsibility. The aim of this effort is to serve as the first step for the development of knowledge and interest in this topic in freshman engineering students.

4. Multinational Collaborative Design Projects

In Penn State, all freshman engineering students are required to take the introduction to engineering design course. In the Brandywine campus, this course has been structured to introduce engineering students not only to the engineering design and decision making process but also to promote professional skills such as teamwork, ethics, global awareness, and communication methods including graphical, oral and written. This course uses a project-based learning approach (PBL) and students work in two projects during the semester. The first project is related to the reverse engineering and redesign of a small product. Toys and electric toothbrushes have been used since they are inexpensive, easy to manipulate, and contain electrical, mechanical, structural and programming parts. During this project students are required to dissect the product, learn about its operation, describe the how the product works as a system, and then go through a market analysis and the design process to redesign it. The second project is more general and open. Students are challenged to design a product or a system to satisfy certain requirements. Since 2005, this second project has been a multinational collaborative design project, and it has been used to foster global awareness, multinational teamwork, use of technologies for communication, and, more recently, global ethics and social responsibility. In this section, this project will be described and how has been transformed to reach the desired objectives.

4.1 Structure of Collaborative Design Projects

There are different types of international projects that can vary from a very simple case study where a team reports a final result of a design to their opposite group to a more complex integrated team project where students from multiple countries work together on a joint design project (Jenkinson, et.al., 2000). The criteria to select the appropriate type of collaboration depend on the general objective, the level and content of the course, the commitment of faculty and the students, and the resources. The scheme structure selected for the collaboration in the introductory engineering design course consists of a parallel design project in which students at each institution work independently in the same project but they are encourage to share and discuss data and ideas in the solution of the problem.

This type of global collaborative projects is possible only if a collaborative network among instructors and students at different institutions in different countries is established. Since this initiative started in 2005, more than 400 students from seven different countries (Brazil, Colombia, Dominican Republic, Ecuador, Honduras, Peru, and US) have participated is the collaborative networks. Depending on the number of teams from different countries participating each semester, the collaborative network is formed. Figure 2 shows a typical collaborating network. As can be seen in that figure, clusters of collaboration are formed with teams from different institutions. It is also desired that each cluster have teams from different countries. In some cases those clusters have had up to four different teams and in other cases the cluster has been limited to two teams. Originally, collaborative pairs were formed but as the experience has grown the collaborative pair model was transformed into a collaborative cluster.

Figure 2: Collaborative Network

4.2 PROJECT METHODOLOGY

The project follows the design process, and activities locally and internationally happen along the process. Students are required to discuss the design challenge locally and then exchange information with their international partners to obtain more information with a different perspective including cultural and social factors not considered or simply ignored by the local teams. Figure 3 shows the design methodology used for the project highlingthing local and international activities, and figure 4 shows a typical chronogram of activities. As it can be seen in figure 4, the project is scheduled for eight weeks and the international collaboration takes place during five weeks. This is to manage the different schedules for the semesters in the different countries.

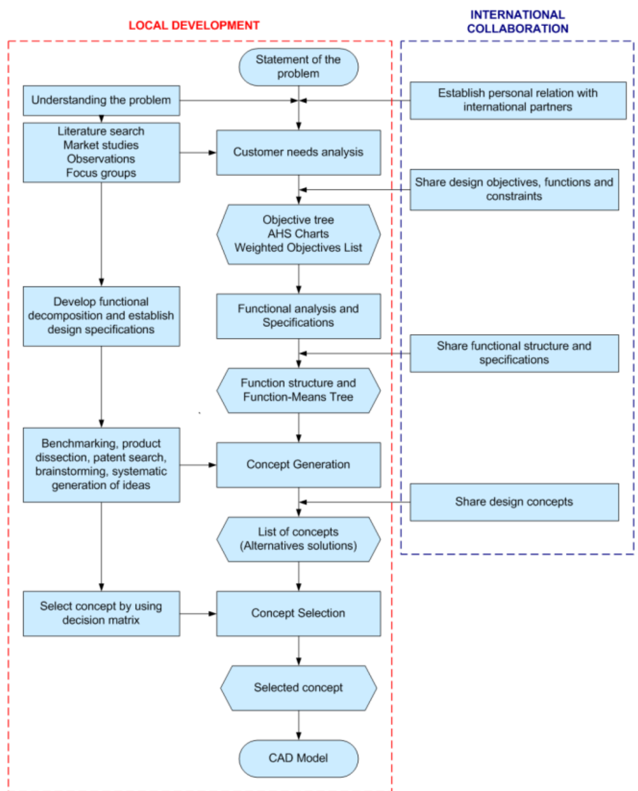

Figure 3: Design Methodology for the Project

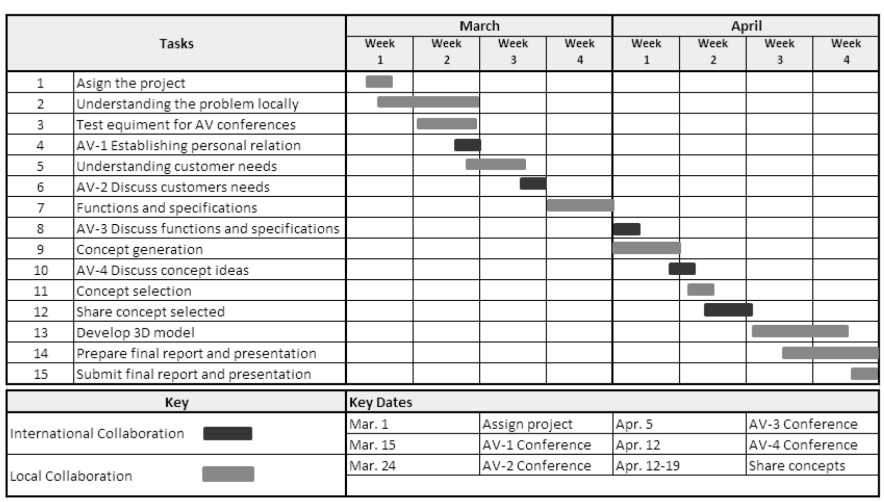

Figure 4: Chronogram of Activities

The projects considered in this initiative are global in scope and with ethical, social and environmental implications with the aim of enhancing global social responsibility in freshman engineering students. The design process is complemented with a set of questions where students are guided to consider all the issues mentioned before while they are going through the process of design. This is the way to face the students with real issues of social responsibility at a global level while they are solving engineering challenges. They are expecting to reflect based on the questions given at each step of the process. Table 1 shows the design steps and the questions given to trigger the discussion during the design process.

Table 1 Design approach for multinational design project

Activity	Trigger Questions Approach
Understanding customer needs	1. Identify stakeholders (all people with interest in this project or might be affected for this project). 2. Identify non-human living species that might be affected by this project. 3. Gather information from stakeholders a. Consider local information b. Consider global information (from your international partners). 4. Translate stakeholders desires into product requirements a. Can you include requirements for the non-human living species? b. Can you anticipate the cultural and social impact of your solution? c. Can you anticipate an environmental impact during manufacturing, operation, service, and final disposal of this product?
Functions and specifications	1. Create a black-box model a. Can you anticipate in or out flows that might have a negative impact (cultural, social, and/or environmental)? Consider short and long term impact. 2. Create a transparent-box model a. Can you anticipate internal flows that might have a negative impact (cultural, social, and/or environmental)? Consider short and long term impact. 3. List product specifications a. Can you identify critical specifications that might have to be monitored closely for negative impact?
Concept generation	1. External search a. Patent search. Do you have access to international databases? Did you consider them? b. Benchmarking (can you identify social and cultural versions and safety or environmental issues in existing products?) c. Can you identify cultural, social, environmental, and/or ethical issues that might affect your concepts? 2. Internal search a. Basic methods (intuitive). Direct methods (logical) (consider alternatives that are safe, cultural and socially accepted, and has a minimum impact in all living species and the environment during manufacture, assembly, use, service and final disposal)
Concept selection	1. Use decision matrix for concept selection a. When evaluating alternatives take into consideration not only the business (cost/profit model) aspect of the product but also the cultural, social and sustainable aspects, and the overall impact in the society (locally and globally).

4.3 PROJECT THEMES

As mentioned before, most of the projects, have been selected to have a global scope and strong social and/or environmental component. This is with the aim of cultivating the global social responsibility from the first year in engineering students. Table 2 summarizes some of the projects that have been part of this initiative and that promotes the values of global social responsibility.

Table 2 Global collaborative design projects

Design Project	General Statement
Portable and folding bicycle	The high cost of the cars and fuel, the contamination of the environment, the congested traffic, and the saturation of the public transportation system in the cities has generated the need to seek economical and no-contaminants alternatives for the transportation of the people. Design a portable and folding bicycle that can be stored in a backpack. The basic requirement is that can be carried by a person without any inconvenience. This bike will be utilized like complement of urban systems of massive transportation.
Lifting wheelchair	Wheelchair users are limited to reach objects up to certain height since they are limited to the height of the wheelchair. Your task is to design a wheelchair capable of providing vertical displacement of one meter above the floor and rotation of 180° for the user (the seat of the chair should be able to rise and turn). The intended design is for paraplegic wheelchair users with normal or low strength or flexibility in their arms and hands.
Wheelchair accessible refrigerator	Wheelchair users have difficulty accessing a common refrigerator. They cannot reach products which are located at certain level or certain depth in the refrigerator due to their physical limitations. Design a wheelchair accessible refrigerator with a minimum capacity of 18 cu. ft. The users should be able to reach all the compartments and all the objects in the refrigerator from their wheelchair without any additional physical effort.
Commercial can crusher	The campus is committed to preserving the environment by having a recycling program for paper and soda cans; however, it is concerned about the volume of soda cans left in the recycling bins. The campus has contacted a recycling company and they are interested in collecting the soda cans from the campus but they need it crushed to a minimum of 10% of the original volume of the soda can. Design a can crusher that can be installed at different points through the campus. The apparatus should also have a storage bin to collect the crushed cans, a mechanism to remove the tabs before crushing, and a bin to collect the tabs. The mechanism must be accessible by the whole community including students in wheelchairs and it should be easy to use even for a person with limited physical strength.
Agricultural transport system for a portable power source	Design an affordable system to transport a portable power source (you have to decide which power source you would like to have in the solution) capable of driving the following attachments: a water pump, a portable water well drilling rig, and a rotary-plow (rotary tiller). The system is also capable of transporting at least one person and the required attachment through the terrain of a farm. The final design is intended to be manufactured in the Latin American countries
Design of leg prosthesis for kids	Anti-personal (AP) mines are a worldwide problem. According to recent studies there are more than 80 countries around the world with affected by landmines and the numbers vary from 50 to 300 million landmines lying hidden through the world. Each year many children are killed or mutilated due to these mines. Design leg prosthesis to be used by kids from 5 to 18 years. The prosthesis should be adjustable or adaptable so the kids can use it and adjust it as they grow. The prosthesis should be affordable and easy to manufacture, assemble and use. The final design is intended to be manufactured in the Latin American countries
Design of a collapsible/portable housing for refugees	Many people around the world are displaced from their homes due to war conflicts or natural disasters. They need to find emergency shelters and proper living conditions while their situation is permanently resolved. Therefore, there is a need to develop an

	inexpensive, collapsible and portable housing to be used as shelter. The concept might be extended as a solution for homeless in very deprived communities. Design a collapsible and portable housing that is inexpensive, safe, durable and able to protect the occupants against inclement weather (consider minimum rain, snow, low and high temperatures, and winds up to 40 mph). The housing will accommodate minimum four people, and should be able to be installed in any type of surface by no more than two persons. The housing is intended to provide a safe area for the occupants to stay and sleep, and maintain the dignity of the users.
Automatic sorting machine for recycling	Latin American countries are interested in fostering recycling programs to reduce energy usage and environmental pollution. Now, many places including malls and academic campuses are using recycling bins for final disposal of beverage containers. Traditionally a common bin is being used to collect plastic bottles and aluminum cans similar to those in the US. However, small recycling companies in LA are only interested in either the plastic or the aluminum containers and they don't have the infrastructure to sort the materials and they are only interested in one type of material. Design an automatic machine to sort plastic bottles and aluminum cans that can be used in different settings (malls, shopping centers, academic institutions, office buildings). The machine should be able to receive the bottles and cans in any order and position and should be able to sort and classified them into different bins depending on the material. For plastic bottles consider standard sizes from 8 fl-oz to 64 fl-oz (237 mL to 1880 mL). For cans consider the standard size of 12 fl-oz (355 mL).
Design a machine to produce charcoal briquettes from sugarcane bagasse	Sugarcane is grown in many regions in Latin American countries with tropical climate. The sugarcane is used to produce table sugar, rum and alcohols, particularly ethanol among other things. The bagasse that remains after the sugarcane is crushed to extract its juice can be burned to provide heat. In many towns where sugarcane is cultivated, families are poor and don't have easy and affordable access to energy, and the bagasse is a good and affordable energy source for them. There is an interest to produce charcoal briquettes by burning the bagasse, carbonizing it and pressed into bricks with the aim of reducing the storage area required by the bagasse, and obtaining a product that is much easier to manipulate, and that is free of smoke, making it viable for indoor cooking. Design a machine to produce charcoal briquettes from sugarcane bagasse. The machine is to be manufactured and operated in Latin America, and to be used by people in small and deprived villages. Keep in mind the limited access to energy in the villages this machine will be used.
Design of a portable non electric laundry washing machine	In deprived communities in Latin American countries, women spend many hours during the week (more than eight hours for a family of four) washing the clothes. According to the Open Source Washing Machine Project (OSWMP), most of the people in this planet, mostly women, wash clothes by hand in harsh conditions related to poverty, lack of sanitation, water or energy. Design a portable non electric laundry washing machine with a minimum capacity of 2.5 cu ft. The machine is to be manufactured and operated in Latin America, and to be used by people in small and deprived villages.
Solar water distiller	A deprived community of 350 people approximately has access to raw water from a creek during the raining season or from the ocean during the dry season. They are in need of having purified water for drinking and cooking in a sustainable way. This community is located in Boca Tocino, Atlántico, Colombia and the distance to the creek is about 50 meters and to the ocean is about 150 meters longitudinally with an elevation of about 10 meters with respect to both the creek and the ocean. Design a solar water distiller system to purify raw water from the creek and salt water from the ocean. The system must work continuously and include a tank to store at least one gallon per day per person. When water is purified from salt water, the remaining salt should be collected for other uses. This community has limited access to electricity. The system is to be operated and maintain by the community so simplicity is required.

5. CONCLUSIONS

The introduction of multinational collaborative design projects in the freshman engineering design course provides an opportunity for students to start developing social responsibility in a global context. The set of questions they are required to consider while going through the design process make them to reflect in cultural, social, ethical and environmental issues that under other circumstances they would have completely ignored. Additionally, some of the design challenges given to the students ask them to find solutions for deprived communities in developing countries which make them to reflect in more detail their solutions since they cannot come up with concepts which are not applicable and/or sustainable in other cultures, economies and social realities.

Besides that, this type of activity provides also opportunities for the students to interact with peers from other countries so they can start appreciating other cultures and social perspectives. It allows starting developing global competencies such as global awareness, multinational teamwork, and communication in international settings which are critical to be competitive in the global market. This is also a great opportunity for engineering students to start becoming familiar with the use of technology for communication in a professional environment.

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