DEVELOPMENT OF KEY PROFESSIONAL SKILLS THROUGH BIOMEDICAL SOCIAL PROJECTS WITH ENGINEERING STUDENTS

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Abstract

Technology transfer mechanisms are a proven way to ensure that the developments in universities from labs and classrooms are taken to the next step, most importantly to allow these to reach their target users and make a significant impact in the community. Medicine has benefited considerably from new technological developments, increasing the quality and effectiveness of services delivered to patients. New technologies are often expensive and only available in private or specialized hospitals, which is the case of México. One way to reach the most vulnerable sectors of the population is the development of technology-based biomedical solutions created to democratize healthcare at a lower cost. This idea implies a challenge to students and professors in universities, but it has been observed that the outcomes from these innovative learning projects are the increase in professional skills like social engagement, resilience, entrepreneurship, and development of engineering solutions.

Introduction

Innovation in the classroom and the application of new didactic techniques have been the core tools of universities as a strategy to ensure academic quality and an enriching learning experience for students. Engineering students are being educated in core subjects from science and technology with the vision of applying this knowledge in the resolution of problems within their organizations (Mills and Treagust 2003). Companies want highly qualified personnel capable of designing and executing effective solutions and process improvement within the organization. We live in a fast-paced era when technological innovations and the global socio-economic landscape are redefining the rules for organizations as well as requiring professionals with key soft skills who are capable of working in a diverse environment (Belli 2016). As educators, we face the challenge of educating the new generations of engineers ready to solve problems that do not exist today, those that we have no information about. The conclusion reached by academic institutions is that development of skills and competencies in students is very important (Observatorio de Innovación Educativa del Tecnológico de Monterrey 2015); students with a strong theoretical basis plus some professional skills will be ready to perform successfully in their future professions. In spite of the unknown future landscape, the students will have the tools necessary to solve any challenges using not only their disciplinary knowledge but also the skills acquired during their university life (Clawson 2014).

Efforts are being made by higher education institutions to prepare students not only academically but training them in soft skills for their professional development and performance. New education techniques like challenge based learning and evaluation per competencies are

aiming to prepare students for an uncertain future of global competitiveness (Apple, Inc 2009). In this paper we present as a case study the efforts made by the ITESM Campus León in changing the education model using different teaching-learning strategies, focused primarily on encouraging students to solve pressing issues in Mexican healthcare by showing the progress, the results, and the findings from these projects. Biomedical projects linked to social needs have generated benefits to the community and also have had an impact in students' education as future entrepreneurs and socially responsible professionals.

About the Tecnológico de Monterrey

The projects described in this paper were performed in the Tecnológico de Monterrey, which is also known as ITESM. Founded in 1943 as a nonprofit association, ITESM is a private higher education institution independent of, and not related to, any political party or religious group. It is a multi-campus university system with centers in different cities across the country and link offices in different parts of the world (Tecnológico de Monterrey 2016).

The work of the ITESM and all its campuses is supported by civil associations with national leaders from the industrial sector and other interested parties committed to promoting quality in higher education. ITESM has been accredited by Mexican and international agencies both as an institution and for its academic programs. In particular, it has been accredited by the Southern Association of Colleges and Schools (SACS 2016).

Previous Strategies

Using different didactic techniques (e.g., project-oriented learning, collaborative learning, problem-based learning) and convinced of the importance of practice on effective learning, ITESM has been distinguished by the approach of "learn by doing" encouraged for engineering students. One of the most representative projects within this strategy is the "Robolympics" event aimed to develop active learning through technology-based projects. The challenge has been presented to students in their first semester of the bachelor in Mechatronics engineering since 2005. They are asked to design, build, and test an R/C combat robot to fight against others in a competition (López Ramírez and Muñoz Velázquez 2008). During the development of the project, students have a first taste of project management, effective planning, collaborative work, conflict management, and creative problem solving techniques. The project has proven appropriate to kickstart professional skills in students during their first year and as a strong basis for further challenges during their education. However, an important aspect was missing and this was the social engagement: students needed to envision how to transcend from their discipline to their community. Therefore actions were taken and academic projects were designed in order to challenge students to solve social issues using a responsible and entrepreneurial mindset.

Evolution of Biomedical Projects at ITESM Campus León

Multidisciplinary Projects

The first strategy attempted at the León campus were multidisciplinary projects where students from all the different bachelors at the campus (Business, Engineering, Art and Design) worked together in teams during one semester in a common challenge, mentored by their professors and external advisors in the field. This strategy was implemented from 2010 to 2013.

The first of its kind was the "Avanti" project in 2010. The challenge presented was to design an intelligent vehicle for the Mexican elderly by 2020 (López Ramírez, et al. 2010). This was an international project with experts from Mexico, Spain, Italy, and the United Kingdom. Twenty-three teams of five students each

from different degree areas presented their proposals. One of the key elements of the challenge to be included with the solutions proposed was a vital signs telemonitoring system, capable of obtaining user data and transmitting it to caregivers and relatives. The social impact of the project was aimed at empowering a neglected group in the community. Elderly people often have a fear of leaving home due to risks and uncertainty, but crave mechanisms that might help them to be more independent and productive. The telemonitoring system in the vehicle allowed the users to leave home and run errands knowing that if something happened to them during a commute, caregivers and relatives would be informed immediately and fast medical assistance would be provided.

Students received weekly lectures via Skype from the faculty and the mentors in Italy, developing a overall understanding of the problem, business generation, and feedback on the proposals developed before the final delivery of the project. Coupled with the online mentoring sessions with Italian designers, students divided into groups for specialized workshops on related topics, like sustainability, car design, ergonomics, rendering, and biopontentials. All lectures and workshops were oriented to expose them to up to date information regarding the most important topics for project development. In different stages of the schedule, workshops for teambuilding skills, oral presentations, personal marketing, etc. were given in order to develop the required soft skills for the successful completion of the project tasks, especially those required for multidisciplinary work and effective presentations.

The project resulted in several proposals, one being awarded second place at an international automotive competition "Product Development Process Andrea Pininfarina Award" in Italy (Desktop Engineering Editors 2010). The project was further developed and enrolled into the business incubator of the Technology Park at the campus (Fernández 2013). Subsequently the project was recognized and supported by CIEL Social Incubator (from the Coca-Cola Company) and featured in the series "Planet of Ideas: Transforming the Future" on Discovery Channel for Latin America (El Informador 2013). This resulted in the first experience in which students worked collaboratively in multidisciplinary teams to solve a common challenge. Observation and further evaluation of students' development showed that skills like resilience, multidisciplinary work, and entrepreneurship were developed, but most importantly, students started to recognize social-impact projects as opportunities for professional development.

The multidisciplinary projects became more challenging through the years and adapted to technological trends. One project from 2013 called "Mindapps" focused on the development of mobile applications for the health sector. One-hundred seventeen students from different bachelors were divided in 23 teams, which investigated and identified problems and proposed solutions to these through engaging apps. Among the different apps, platforms were developed to help users find pharmacies or hospitals when they suffered certain illnesses, and the app also suggested basic remedies while medical care was given. One app connected sensors to a mobile device obtaining physiological signals from the user, collecting data and uploading it to a hub to be easily accessible by physicians and hospitals and recording the information in a customized medical history. The app was also designed to remind the user about medication intake and to communicate with the user's relatives in case of an emergency situation. The result was that students used one of the most innovative tools available nowadays, the mobile app, to create simple solutions to specific healthcare needs. Their oral presentation skills, empathy, and user empowerment

were increased, especially because they had chosen their project and the impact they wanted to see in other people suffering from chronic diseases or elderly patients.

Inclusion of Biomedical Challenges in Engineering Subjects

Considering the global megatrend of the aging of population and the increase of chronic-degenerative diseases, special strategies are being outlined by local and state governments to promote the development of a health cluster attending to the future needs of the healthcare system. This focus has been included in the curriculum since 2014 challenges oriented to solve health issues and in different lectures of mechatronics engineering like Mechatronic Design, Projects of Mechatronics Engineering, and within the elective "Topics of Biomedical Engineering." Given the formation of students as engineers during the bachelor, they attend these lectures during their final year, applying the technical knowledge to the resolution of a problem of their choice with impact on medicine. Students get out from their comfort zone and explore within the community the most pressing issues suffered by people from vulnerable sectors. This helps them to sensitize to the reality and problems of others, but mostly gave them a motivation they never had before: they realized that they could make a change by applying their knowledge in class-projects. The resulting projects were a low-cost 3D myoelectric hand prosthesis for amputees, accessible rehabilitation machines, and comfortable ergonomic vital signs monitors based on novel low-cost technologies.

Due to the lack of a formal foundations in biomedical topics, students developed a self-learning capacity. The prototypes developed reached a higher level of complexity and quality than ones from previous generations, some of them still being re-designed and developed with aims to be delivered to the target users and patients that wouldn't have access to these therapies and technologies due to high-costs and technical complexity.

New Scheme of Social Service

Current Implementation of the TEC21 New Education Model

Regional interest in strengthening the healthcare sector and the global technological trend of developing novel biomedical products motivated the ITESM to carry out a new innovative education model with a special strategy oriented to have a clear benefit to society. This new model is the TEC21 model, oriented to prepare students that are leaders, with entrepreneurial spirit, committed to their communities and competitive internationally (Centro de Desarrollo Docente e Innovación Educativa 2015). To accomplish this vision, the ITESM designed and has executed since summer of 2015 the pilot program of the new social service scheme. This pilot program is designed to include high social impact projects during the duration of a student's university career, developing soft skills as well providing real-life experimentation and application of the knowledge acquired in the classroom with a high commitment to society.

For the students of Mechatronics engineering bachelor at the ITESM León campus, the program was adapted to engage them in improving the health of the population through a culture of prevention and self-awareness in collaboration with different health care institutions, with the goal of having a direct impact on quality of life in vulnerable sectors. The pilot started in August 2015 and is ongoing, finishing the first stage in May 2016. The implementation of this new scheme responded to the fact that engineers are educated to solve specific tasks or already identified problems, but are not ready for a world that demands solutions for problems not defined within an engineering context.

Students of different semesters from Mechatronics enrolled in selected key lectures of electronics were part of the

program. Teachers covered the engineering curriculum established for the lecture but also connected this context to the medical applications. Students were taken to the ALDIM association (León Association for Muscular Dystrophy), where patients with low incomes suffering from muscular dystrophy or who are movement-impaired receive rehabilitation and specialized therapies at a low-cost (Asociación Leonesa para la Distrofia Muscular AC 2010). The first part of the pilot consisted of needs-finding from the students' side and the generation of proposed solutions adequate to the daily problems encountered by the patients, their caregivers, and relatives. The tools used were based in different design methodologies adapted for this particular case, for example the IDEO toolkit for Human Centered Design. This helped to change the paradigm of how mechatronic projects start; students changed from waiting for a faculty's proposal to elaborating their own proposals. There were a total of 36 students divided in two groups (from Electronics and DC circuits lectures).

The result was the practice and real-life connection of engineering topics into the resolution of medical problems, where students by engaging with patients widened their horizons and explored new possibilities of application of their knowledge. Most importantly, they developed a deep sense of social engagement and creativity, being motivated to continue the research and development of solutions in the following semesters and demanding their faculty work on the prototypes until they are fully ready to be used by the patients. From the faculty side, it posed a challenge, but helped to sensitize lecturers in other project areas for future collaboration. In general, projects with a biomedical approach and with impact for vulnerable sectors are more challenging in nature, but in the faculty's opinion, the benefits are greater. Lecturers adapted and engaged with the projects and it helped them to explore new areas where high impact projects could be developed with a direct relationship to social responsibility.

Conclusions and Future Work

Given outcomes of the multidisciplinary projects, common semester student projects became multidisciplinary by nature, setting the path for new education strategies to be implemented. Still, work has to be done in order to allow multidisciplinarity to occur more naturally in the university's ecosystem. The institutional attempts mentioned focusing on the implementation of medical projects in the lectures started to show evidence of the development of key skills in students currently demanded in the job market. Moreover, students started to see beyond their engineering field and identified business opportunities in technology-based, low-cost and high social impact products and services.

The role of the professor changed to become that of guide and mentor. Professors had to sensitize and live the experience with their students, improving the feedback and assessment given during project development. Within the challenges encountered, we found that students need more preparation in business model generation and engineering design techniques, in order to promote the entrepreneurial mindset as well as to improve the methods currently used to find solutions faster and more structured to the user's needs. Further development and reinforcement of creativity and innovation should be made in the different project-based lectures to prepare students with better project management and execution techniques.

For future iterations of the program, special workshops will be given to both students and faculty to sensitize them for every stage of the work with users (patients), from the first visits to iterated work and prototype validation. Experiences from students were gathered via final reports; deeper evaluations of students will be

designed and applied in order to evaluate fully and obtain statistical data of students' development, learning, and experiences.

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