Collaborative technological development and innovation between UTRGV-ENGT, USA and ITM-CSE, Mexico: An Intelligent Closet Prototype

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Abstract

This paper describe an interesting cross-border collaboration between The University of Texas Rio Grande Valley (UTRGV) – College of Engineering and Computer Science (CECS) Department of Manufacturing and Industrial Engineering (MIE) – Engineering Technology program (ENGT), and Tecnológico Nacional de Mexico / Instituto Tecnológico de Matamoros (TecNM/ITM) – Computer Systems Engineering program (CSE). The collective efforts gave as a result the development of a completely functional automation prototype, designed, built and coded by students of both regional leader institutions in higher education. With this undergraduate research in technology development and innovation, both institutions start the cooperative work, leading efforts towards effective and strong cross-border collaboration. The project was a great opportunity to coordinate future research, taking advantage of our strategic geographic location and identify future research opportunities to contribute to the economic development and social wellness, in both sides of the border, due to its distinctive characteristics – economic development, culture, language, etc. In this paper we include a description of the enrolled programs, the collaboration method, monitoring and evaluation, lessons learned, resultant outcomes, challenges and opportunities for growth.

Introduction

“Among the states of northern Mexico, Tamaulipas is less developed in regard to policies and institutions supporting innovation, science, and technology. The northern states, and specifically the border cities, are the best-positioned regions for innovation. This is confirmed by the sustainable competitive index, government programs, universities, and research centers.”

Due to its distinctive characteristics – economic development, culture, language, etc. – the border USA-Mexico is indeed a region with particular challenges, as well as opportunities, which go beyond any boundary. These particular obstacles enhance the importance of the region known as the Rio Grande Valley to turn it into a transformative and integrative axis in the globalization course for both countries.

These challenges place the higher education institutions in a role of great responsibility with great opportunities: new strategies on demand for innovative collaboration are to be developed; the main goal is set to streamline projects for basic and applied research in technological development, innovation, and entrepreneurship, spreading the results and its effectiveness.

Therefore, UTRGV campus Brownsville and TecNM/ITM, as leader institutions in higher education, accept the challenge and actively work together towards cross-border collaboration schemes, in order to contribute to the economic development and social wellness, on both sides of the border. This collaboration can be defined as innovative because we are centering efforts towards a new student interaction, besides academic student exchange programs.
A successful example of these collective efforts is the development of a completely functional automation prototype, designed, built and coded by UTRGV-ENGT and TecNM/ITM-CSE students, as part of their graduation requirements, led by faculty from both institutions. The results promote collaborative partnership for future basic and applied research settings, towards a cooperative cross-border Rio Grande Valley region, focusing on the social, industrial and manufacturing needs by providing solutions to the economic and developmental problems of this particular region.

This rest of the paper is organized as follows: first we give a brief review of the higher education and industrial significant features in the region, subsequently, we describe the process during the development of a senior design project between UTRGV – CECS – ENGT, and TecNM/ITM – CSE, including a description of the enrolled programs, the collaboration method, monitoring and evaluation, lessons learned and resultant outcomes. Next, challenges and opportunities for growth are discussed; finally we present our concluding remarks.

Background

Due to its strategic geographic location, the Rio Grande Valley, in southeast Texas, and the northeast of Tamaulipas, Mexico, offers a valuable trading zone, ideal for the international investors considering expanding their industrial and manufacturing companies, with the added value of the access to markets in the United States, southern Canada, and envisioning the growth to Europe, Asia and Latin America.

“The Texas-Mexico border is a fast-growing region, a complex blend of U.S. and Mexican cultures, languages and customs. It is a dynamic area that has benefited from a large and growing population in Mexico, rapid growth in U.S.-Mexico trade and a tenfold increase in maquiladora industry activity of the past two decades. Total population in the four Texas border metropolitan statistical areas (MSAs), Brownsville, El Paso, Laredo, and McAllen, is about 1.8 million, and population growth since 1980 has been 65 percent, versus 24 percent nationally.”

This region is recognized worldwide for its broad diversity in the manufacturing sector, with over 40 years of expertise in the automotive, electrical-electronic, medical and metal-mechanic sectors. In order to increase the quality of the services offered and the manufacturing competencies, a regional cooperation is imperative, and cross-border collaboration can provide an effective strategy for strengthening high education in the region. A high-quality education creates the foundation of a sustainable basis of human resource to build and uphold a country’s development and in this region we are privileged to have two major high education sources: The University of Texas Rio Grande Valley, in Brownsville, TX, USA, and Tecnológico Nacional de Mexico / Instituto Tecnológico de Matamoros, in Matamoros, Tamaulipas, Mexico.

UTRGV was created by the Texas Legislature in 2013, in an unprecedented and remarkable move that brings together the assets of two regional high education institutions: UT Brownsville and UT Pan America. As a new institution, UTRGV is projecting to grow as an emerging regional research institution, and cross-border collaboration will provide an opportunity to better serve the over 3.5M people in a 150 mile-wide region. The University aims to transform Texas and the nation through student success, research, healthcare, and commercialization of university discoveries.
The UTRGV – CECS offers course work and cutting-edge research with international impact. As part of a new institution, CECS has projected to provide the community with a path to a better life built on compassion, community and technology, through a comprehensive education for student-success delivered by accomplished and passionate scholars supported by professional and caring staff.

The ITM is leader higher education institution in the region and is one of the 266 campuses throughout of TecNM, the largest higher education institutional network in Mexico. The TecNM offers undergraduate and graduate programs focused on professional training in technology. The TecNM has a presence in all 32 states of the Mexico and provides a high-quality educational opportunity to approximately 580,000 undergraduate and graduate students, mainly from low-income families. The TecNM enroll students in 37 engineering programs and 97 graduate programs. The TecNM has operated tirelessly in its national vision to “be one of the fundamental pillars of sustainable and equitable development of the nation”\(^5\). In order to accomplish this goal, the institutional mission explores and implement pioneering paths to provide high-quality technological education services with national coverage, relevant and equitable, which contributes to the creation of a just and humane society, with a perspective of sustainability.

Towards effective and strong cross-border collaboration: a capstone project

Capstone projects have been identified as a significant element for engineering education; during the development of the project, the engineering students get the opportunity to research possible solutions to an actual problem, working with academic advisors and industry personnel to analyze production problem and design, and system development.

The capstone project includes the application of skills, knowledge, techniques and concepts in the design and manufacturing. Emphasis is placed on project management, documentation, and presentation. Teams will formulate research projects in conjunction with department faculty and industry partner to identify an existing or expected industrial problem, to complete in two consecutive semesters.

The Intelligent Closet Prototype is a technology development and innovation project planned to engage senior students, from both higher learning institutions, to train multidisciplinary teams and practice knowledge learned during their engineering coursework. The project titled: “The Intelligent Closet, an overview of an experimental design in order to automate the process of selecting or storing of clothing in a simplified manner within a typical closet”, was elaborated by three students from the UTRGV– CECS– ENGT Senior Design I/II course and three students from the TecNM/ITM – CSE.

The cross-border multidisciplinary team was directed faculty: Two faculty members from the UTRGV-ENGT and one faculty member from the TecNM/ITM. (Dr. Immanuel A. Edinbarough, Adriana Olvera, and Dr. Anabel Pineda Briseño).

Enrolled Engineering Programs

According to the official description, the ENGT program is described as “the profession in which knowledge of mathematics and natural science, gained by higher education, experience, and practice, is devoted primarily to the implementation and extension of existing technology for the benefit of humanity. Engineering Technology education focuses primarily
on the applied aspects of science and that portion of the technological spectrum closest to product improvement, industrial practices, and engineering operational functions.

The CSE defines its commitment “to train leading, analytical, critical and creative professionals with strategic visions and broad ethical sense, capable of designing, implementing and managing computational infrastructure to provide innovative solutions for the benefit of society, in a global, multidisciplinary and sustainable context.”

Collaborative Cross-border Method

- Technology development and innovation were the benchmarks for this project: an intelligent closet was the proposed project, open for future improvements and aligned to the IoT smart environments research area, with application in scenarios of Industrial Internet of Things, Smart Health, Smart Agroindustry, Smart Cities, as examples of regional priority areas.
- The students were expected to apply the skills learned throughout their coursework: design systems, components, or processes for a specific engineering problem.
- A multidisciplinary team was essential to better solve this project: for the student to prove proficient as a member or leader of a technical team, and to complement professional profiles.

Monitoring and Evaluation

With this tool, students and faculty advisors define at the beginning of the project: the objectives, the project phases, activities and the timeline for the project development. A document is created and updated by the student on a weekly basis. Meetings are held in the same frequency with the supervisor to review progress and discuss problems encountered.

The outcome in this report is a logbook of the activities related to the project and the commitment of the student to overcome the challenges faced during the process. During this process, the students receive feedback to help them make an adjustment or improve the progress of their project. A rubric is used to assess the successful completion of the report.

The creation of a planning analysis and progress plan is a fundamental tool to set the foundation of the student preparation and growth, according to the specific needs and requirements for each project; this tool is intended to turn the student in a life-learner. This process is designed to reflect on existing experiences and competencies; identifying needs to enable successful completion of the project, as well as the opportunities for addressing the project needs.

Progress Report

Student and supervisor must review and complete a document with specific courses and activities related to the aspects relevant to the project, such as the specific academic skills and specific craft skills. The resulting document is a report with the planning analysis, the specific activities to fulfill those needs and the description of the impact of the learning experience. The resultant indicator is a percentage of completion of all the activities planned at the beginning of the process compared to the activities completed at the end of the project.
Type of academic credit granted

The main objective of this collaboration in technological development and innovation during the senior design course is to provide the students an original alternative to validate their competencies (knowledge, technical skills, and attitudes) during their professional training.

At the end of the course, the UTRGV-ENGT program students must submit the following items to successfully pass the course and earn the individual course credits: 1) A technical research report, 2) the project binder, providing evidence of the project progress, 3) a functional prototype, model or experiment, and 4) the final presentation.

The students from TecNM/ITM-CSE must report individually their final work in the form of a: 1) Research and/or Technological Development Project, 2) Technological Innovation Project or 3) Bachelor Thesis, according to operating rules of Chapter 14th “Guideline for Integral Degree” of the Manual of Academic-Administrative Guidelines of the TecNM, to validate these competencies and achieve their integral degree.

Reflection and Self-development assessment

An individual reflection and self-development evaluation is recommended to be recorded in the form of an essay, including the achievements, learning experience, challenges faced, cultural and professional experiences, networking, the impact on their development as professionals, and the opportunities for improvement. This document is submitted to the e-portfolio at the end of the project. The faculty advisors will collect information such as opportunities for improvement and best practices to be applied in following projects.

Resultant Outcomes of Cross-Border Collaboration

The ultimate goal is to provide the student with the opportunity to develop a project that includes the application of skills, knowledge, and techniques, concepts in the design and manufacturing, learned through the engineering program coursework, in a multidisciplinary approach. The students gained practice in preparing and delivering formal technical presentations, and the valuable experience of the impact of engineering solutions in a global context, and the importance of respect for diversity, as described in Table 1, below:
### Prototype

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Learning Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Problem identification</td>
<td>LO1. An ability to select and apply knowledge of mathematics, science, engineering, and technology that require the application of principles and applied procedures or methodologies;</td>
</tr>
<tr>
<td>• Technical detail</td>
<td>LO2. An ability to design systems, components, or processes for broadly-defined engineering problems;</td>
</tr>
<tr>
<td>• Meets customer needs</td>
<td>LO8. Design, integrate and implement computational solutions with different technologies, platforms or devices, current or emergent.</td>
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### Presentation

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Learning Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Participation</td>
<td>LO5. An understanding of and a commitment to address professional and ethical responsibilities including a respect for diversity;</td>
</tr>
<tr>
<td>• Group Assistance</td>
<td>LO3. An ability to function effectively as a member or leader on a technical team;</td>
</tr>
<tr>
<td>• Information Presentation</td>
<td>LO4. An ability to apply written, oral, and graphical communication in both technical and nontechnical environments; and an ability to identify and use appropriate technical literature;</td>
</tr>
<tr>
<td>• Organization</td>
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</tbody>
</table>

### Written Report

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Learning Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Introduction</td>
<td>LO4. An ability to apply written, oral, and graphical communication in both technical and nontechnical environments; and an ability to identify and use appropriate technical literature;</td>
</tr>
<tr>
<td>• Problem Statement</td>
<td></td>
</tr>
<tr>
<td>• Design development</td>
<td>LO6. A knowledge of the impact of engineering solutions in a societal and global context;</td>
</tr>
<tr>
<td>• Final design</td>
<td></td>
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<td>• Testing</td>
<td></td>
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<td>• Visuals</td>
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</tbody>
</table>

### Table 1 Student Learning Outcomes – Collaborative technological development and innovation

Along with the first approach for cross-border research collaboration, UTRGV-ENGT and TecNM/ITM-CSE faculty are working in identifying innovative areas for research, to develop a multidisciplinary cross-border collaborative method, to provide innovative solutions for the regional services and manufacturing industry.
Challenges and Opportunities for Growth

Although certain limitations interfered at early stages in the project development, such as language, limited funding, narrow timeframe for meetings with the complete team, TecNM/ITM students with no US visa or the insecurity across the border, among others, faculty succeed in organizing working separated sessions with students at home institutions, and to coordinate group meetings, for the conveyor testing and debug human, computer and communication interfaces.

The major challenge encountered was the limited number of students at TecNM/ITM with an existing visa, and the restricted commuting from the UTRGV students to Mexico, due to the insecurity environment. The most important requirement for the students from TecNM/ITM was to have completed at least 80% of their program credits in the CSE programming major. Only two out of the four students from TecNM/ITM had a legal document to enter the US; nonetheless, faculty advisors manage to organize the teams, following a working schedule allowing the students to interact remotely via social media, videoconference, and online tutoring. Weekly meetings were designated for individual work at home institutions, with the project advisors. By the end of the project, meetings at the UTRGV Machine Shop were planned, to test and improve communication interfaces.

Opportunities to grow were identified to enhance students’ skills; through the regular completion of assignments during their coursework the objective is to prepare the students for a cross-cultural capstone project:

- To reinforce the learning outcomes with the improvement of multidisciplinary teamwork.
- To give an early response to the regional needs in the automotive industry, manufacturing industry, agroindustry and services such as information and communication technologies (ICTs), energy and health.
- To affiliate with regional industry and manufacturing companies, as higher education regional leaders, to support economic development and social wellness.
In order to incorporate additional engineering programs from TecNM/ITM, different activities are designed with the objective that during subsequent years, this type of collaboration can be replicated with additional engineering groups, interested in join forces to study cross-border multidisciplinary collaboration.

An alternative method is to include Service Learning activities to include high school students interested in pursuing a professional career in the STEM field.

Conclusions and Future Work

As discussed throughout this paper and according to this first cross-border effective collaboration, partnership among UTRGV and TecNM/ITM for technology development and innovation is a strategic program planned for the better understanding of our multicultural cross-border region, to prepare engineering students skilled in multidisciplinary teams, to impact the economic development and social wellness of the border region.

This first successful approach was prepared by creating collaborative and complementary teams pursuing to harness the expertise of various levels of academia of both higher education institutions: EGNT and CSE.

In order to maintain a successful learning environment, collaborative leadership, continuous support from the different institutions, and community involvement are essential component. To ensure sustainability, supportive strategies should be considered, such as promoting collaboration within the institutions, to demonstrate a commitment to prepare border leaders and align the programs particular objectives to support regional strategic goals.

The current cross-border program engagement process is planned to be described in a future article.

Acknowledgments

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References