Expanding Engineering and Technology Opportunities to Students in the Border Region through International Collaboration

Dr. Jesus A Gonzalez-Rodriguez, University of Texas Rio Grande Valley

Dr. Jesus Gonzalez is currently a lecturer in the Department of Manufacturing and Industrial Engineering of the College of Engineering and Computer Science. He holds a PhD from The University of Sheffield in United Kingdom in Materials Science and Engineering. During the PhD, he received the Foster Research Prize given to the best PhD thesis related to glass technology. His research interest is in the mechanical properties of glass at room and high temperature. Dr. Gonzalez has also a broad experience in the glass industry, specifically in fabrication of automotive safety glass. He worked for Vitro Glass Company for more than 19 years where he held different positions such as Process Engineer, Materials Planning and Logistics Manager, Production Superintendent, Manufacturing Engineer and Glass Technologist. During his time in the company, he co-authored two patents related to glass fabrication and glass coatings processing. Dr. Gonzalez is a Six-Sigma Black Belt and has participated in numerous process improvement projects. He has been trained as well in the Methodology of Inventive Problem Solving (TRIZ) that he applied to solve complex problems. In the manufacturing operations field, he is certified in Production and Inventory Management by APICS, which is the professional association for supply chain management. He is a member of the Society of Glass Technology, based in Sheffield England. He is also affiliated to the alumni society of Armourers & Brasiers' Company, London UK, which is a society that promotes the study of Materials Science.

Dr. Immanuel Edinbarough P.E., The University of Texas Rio Grande Valley

Immanuel A. Edinbarough received his B.Sc. (Applied Sciences) degree from PSG College of Technology, University of Madras, India, his B.E.. (M.E.) degree from the Institution of Engineers, India, M.E. (Production Engineering) degree from PSG College of Technology, Bharathiar University, India, and his Ph.D. in mechanical engineering from the Bharathiar University, India. He is currently a professor and director of engineering technology at the University of Texas, Brownsville (UTB). Prior to joining the UTB faculty he was a visiting professor at the Rochester Institute of Technology and an associate professor of production engineering technology at PSG College of Technology, Bharathiar University, India, where he served as the director of the Computer Vision Laboratory and National Cadet Corps – Engineering Division Director. With over 26 years of teaching and research experience in manufacturing/mechanical engineering and engineering technology, he currently teaches in the areas of CAD/CAM/CIM, robotics and automation, product and process design, materials and manufacturing processes, machine design, renewable energy and micro-manufacturing. His current research interests include robotics, CIM, sustainable manufacturing, micro machining and engineering and technology education. He has published several papers in these areas in various national and international conferences and journals. He has worked in heavy and light manufacturing industries, manufacturing pumps, motors, and CNC machine tools in the areas of system design, production planning, and control and manufacturing. Edinbarough also served in paramilitary forces and in the Air Force. He is a Life Member of the ISTE, a senior life member of the IE (India), a member of ASEE and SME, and a licensed Professional Engineer (P.E.) in the state of Texas.

Ms. Adriana Rios Santiago, Texas Southmost College

Adriana Rios Santiago is currently the Architecture Program Coordinator and Instructor at Texas Southmost College (TSC), in Brownsville, Texas. Formerly, she worked as a lecturer of Engineering Technology, in the Department of Manufacturing Engineering at the College of Engineering and Computer Science, The University of Texas Rio Grande Valley (UTRGV), teaching Architectural and Design related courses, and developing undergraduate studies and research in smart environments. She received her Bachelor's in Architecture from Universidad de Monterrey (UDEM), in 2007. She received her Masters in Architecture from the School of Architecture of the Universidad Nacional Autonoma de Mexico (UNAM), in 2011. She is currently pursuing her Doctoral degree in Architecture. Her current research interests include sustainable building design, building automation, and smart environments.

Dr. Anabel Pineda-Briseño, Tecnologico Nacional de Mexico / Instituto Tecnologico de Matamoros

Anabel Pineda Briseño was born in H. Matamoros, Tamaulipas, Mexico in 1978. She received the B. degree in computer systems engineering from the Autonomous University of Tamaulipas, in 2000 and her M.S. and Ph.D. degrees in computer science from the Computer Research Center (CIC) of the Mexican National Polytechnic Institute (IPN), Mexico City, in 2006 and 2013 respectively. Since 2005, she has been a partial professor of computer science with the Tecnologico Nacional de Mexico / Instituto Tecnologico de Matamoros. Dr. Pineda-Briseño is co-creator of the Beyond Engineering Education Program and is professor leader of Arecibo Remote Command Center (ARCC) in Mexico, both projects of engineering and sciences in cross-border collaboration with The University of Texas Rio Grande Valley (UTRGV). Her current research interests are Mobile Ad Hoc Networks (Positioning and Routing Protocols), SDR-based Ad Hoc Space Networks (Positioning and Routing Protocols), Internet of Things, Machine Learning and STEM Education. Currently, Dr. Pineda-Briseño is member of the National System for Researchers (SNI) by the CONACyT in Mexico since 2017.

Expanding Engineering and Technology Opportunities to Students in the Border Region through International Collaboration

Abstract

For some years now, our Department of Engineering Technology of the University of Texas Rio Grande Valley (UTRGV), has collaborated with Universities across the southern border to carry out different activities such as undergraduate research, collaborative course-based projects, and senior design projects. We have observed how students benefit from being exposed to work in multidisciplinary and multicultural teams.

We now expand this form of work to a higher-level research collaboration where students and faculty from four different institutions participate. Two institutions of higher education in Mexico and a University and a Community College in the United States. The collaboration carries out an innovative project that requires the integration of different specialties. The project consists of an intelligent clothing storage and retrieval system that involves artificial intelligence, and a design of a sophisticated electromechanical system that optimizes storage and retrieval and adapts to the needs of people with visual disabilities.

The collaborative effort includes the active participation of the faculty, supported by a team of undergraduate students. An important part of the project includes a master's student from Mexico visiting the UTRGV for three months to collaborate in the project.

Fortunately, The University of Texas System and CONACYT, Mexico's entity in charge of promoting scientific and technological development, have established an initiative to support bi-national academic research and collaboration through the ConTex program. This is an opportunity to apply for the funding needed to take the project to successful completion.

This type of work represents a challenge in international collaboration and the paper discusses not only the benefits but also the way to face these challenges. The pedagogical issues in managing this type of multidisciplinary and multicultural research oriented technological project are presented in the paper. A thorough literature survey on international collaborative projects of similar nature are included in the paper.

Background

The Rio Grande Valley (RGV) in southeast Texas and the north east of Tamaulipas, Mexico is a region known as one of the fastest growing metropolitan areas of the world, holding a regional population of over 3.5 million people, amongst USA and Mexico, and hosts broadly diverse manufacturing industries. As a result, higher learning institutions are working towards incorporating higher education as a dynamic regional element.

The University of Texas Rio Grande Valley (UTRGV), was created in 2013 by the Texas Legislature as an unprecedented and remarkable move to bring together the assets of the two most important regional higher education institutions: The University of Texas at Brownsville (UTB) and The University of Texas Pan American (UTPA) [1]. As a new institution, UTRGV is emerging as a regional research institution working to grow as a leader among minority-serving research institutions.

As a young institution, with an innovative organization, and with two years since it started operations, UTRGV can be proud of a mission on-route: to provide a high quality, innovative, and affordable education to the students of South Texas, Texas, the United States and the world. The University will transform Texas and the nation through student success, research, healthcare, and commercialization of university discoveries[1]. A temporary vision that has become a statement broadly implemented throughout the different Colleges and Schools within UTRGV, engages faculty and staff into expanding the possibilities from the current multicultural and multidisciplinary programs to cross-border collaboration.

Collaboration with universities across the border provides an opportunity to deliver a better service to the bi-national community in the 150 mile-wide RGV region. The legacy institutions had previous experiences in the development of bi-national programs and collaborations, but by promoting cross-border regional collaboration, the new university demonstrate its commitment to prepare the future engineering professionals.

The College of Engineering and Computer Science (CECS) at UTRGV promotes cutting-edge research with international impact as a path to a better life, built on compassion, community, and technology, and foresee every performed activity as a promoter for economic prosperity and commitment to the global community [1]. With an extensive selection of undergraduate programs in the engineering field, the Department of Manufacturing and Industrial Engineering provides a setting for technology development and applied research in the Engineering Technology (ENGT) program. According to the program description, engineering technology education emphasizes primarily on the applied aspects of science and product improvement, industrial practices, and engineering operational functions[2].

Introduction

Considered as an essential contributor to industrial efficiency, the practice of multidisciplinary engineering design teams performs an important role in engineering problem solving and managerial performance[3]. Thus, the capstone engineering course's role in engineering education is essential to prepare the students to resolve industry challenges. Nowadays, innovative methods in teaching, including the cross-cultural student integration have proven effective to enhance success in multidisciplinary engineering design teams[4].

Examples of academic international programs, such as study abroad, student exchange or online courses, allow students to experience certain advantages of cross-cultural education. However, a more active participation would provide the students with opportunities to develop an understanding of working in international settings and gaining the skills to successfully interact with diverse cultures[5,6].

As a bi-national region, we can consider this a privileged geographical area to experience cross-cultural mobility. Therefore, cross-border collaborative learning through capstone engineering projects is developed as a regional, cooperative scheme to provide additional societal settings for technology development in undergraduate applied research for students on both sides of the Rio Grande Valley.

Capstone project description: An Intelligent Closet

The main goal of the capstone project as a cross-border collaborative setting is to engage senior students in multidisciplinary projects in practicing the acquired knowledge during their corresponding coursework. This capstone program is developed as a two consecutive course sequence. During the first semester, students use their time to identify an engineering problem and proceed to develop an optimal solution. It is required to conduct a thorough research on the topic and complete the planning and design of the final project. The subsequent, and last semester is used to build and test the completed prototype model.

The main characteristic of a successful capstone project is the innovation and technological development. The project completed is a totally functional real-size prototype of a clothing, storing and retrieving system: The Intelligent Closet. It was designed following accessibility guidelines, characterized by innovative hardware and software solutions in the domain of home automation; the project primarily focuses on the applied aspects of product innovation, industrial practices, and engineering operational functions, to offer useful services and solutions to disabled and the elderly.

Figure 1. 3D Model - overall closet view within walls.

Figure 2. Fabricated prototype.

The students worked as a team on every single design stages; they discussed the best practices to innovate in the conveyor mechanical system; 3D modeling of design for the parts was required (Figure 1), and the fabrication and assembly process of their own designs was an enriching experience for the students (Figure 2). Once the parts were fabricated, the product assembly process demonstrate to the students the importance of teamwork, as the final product was created.

The software development and communication integration process provided the students with different settings and scenarios to try during the product testing phase. The first version of an automated clothing storage and retrieving system was achieved by incorporating a series of smart environment scenarios in the domains of home automation.

Details of the advance technical project

The first version of the Intelligent Closet[7] was completed through capstone projects and undergraduate research. The success of the collaborative effort between institutions motivated us to take the project to a more advance level and incorporate a graduate student and a technical college due to the increased complexity and the need for expertise in different disciplines.

The new version of the project includes the concepts of artificial intelligence, a new design for the storage and retrieval mechanism, and the optimization of the interior space of the closet. The new scope of the project required to adapt the control of the different devices into a common platform to be able to integrate and handle all the functions. The previous version ran the different control modules in the specific programming protocols of the device manufacturers, complicating the integration of additional functions.

Within the innovative functions of the closet is the ability of the system to allow persons visually impaired to store and retrieve clothes of specific colors and types. When a person approaches the closet to store a garment, the item will be placed in a receptacle where a camera will take a picture and a computer algorithm will identify the color. The user complements the information using the voice to state the type of garment. At this point, the system registers the color, the type, and the slot inside the closet where the item will be stored. Once the garment has been identified and its characteristics recorded, a multi-axis mechanism will take the piece to an empty slot inside the closet. One of the innovations against the previous design is that the mechanism moves only one item instead of the entire rack, reducing the size of the motors and the structure. When the user approaches the closet to retrieve a garment, it is just necessary to use voice commands ordering the color and type of garment needed. The computer has in the registry where the item is located. The computer will confirm availability and will retrieve the garment to the reach of the user. For users with no visual disabilities, the catalog in pictures of the garments stored in the closet will be also available in a display located outside the closet. The user will be able to browse the images and select the clothing that will be retrieved. This feature facilitates the selection and combinations of the clothing by having the images displayed in the touchscreen interface.

The project was divided in the following subsystems to better organize the collaborative work: the image acquisition and algorithm for color identification, voice commands recognition and integration of microphone and speaker, three-axis servo controlled stage to handle for storage and retrieval including storage rack, the display for user interaction, and the internal and external design of the closet. Python$^{©}$ programming language was selected as the main platform to integrate all the subsystems.

The first stage of the project involves to fabricate a small scale prototype to test the functions and debug the system. The second stage will involve obtaining funding to build a full scale prototype.

Higher Level Research Collaboration with border Institutions

The collaborative team was formed by a graduate student in computer science from the *Tecnologico Nacional de Mexico / Instituto Tecnologico de Leon* (TecNM Leon). This student was a research scholar in the UTRGV who stayed for a three month period working in the programming strategy and in the module for color recognition. The team from UTRGV consisted of four undergraduate students and two professors from the engineering technology program working on the coordination of the project and in the electromechanical system. The *Tecnologico Nacional de Mexico / Instituto Tecnologico de Matamoros* (TecNM Matamoros) collaborated in the module for voice recognition and tactile interface through two computer systems engineering students and one professor. The Texas Southmost College carried out the physical design of the closet with the participation of four students and one professor from the Architectural Design program.

Implementation of Cross-border collaboration.

As proposed by Danielle Lake[8], it is essential for higher education institutions to build a means of communication among the disciplines. This option is developed as a strategy for sustainability in education, with the aim of providing transformational knowledge into the learning outcomes of the four different programs.

Therefore, multidisciplinary collaboration is presented as a bridge to establish connections among the different perspectives of a problem. The ultimate goal of the proposed participation, is to present a framework that leads to a broader structure of cross discipline interaction.

Advancements in technology development reveals critical societal problems, complex in its nature, which are not possible to analyze correctly only from one perspective. Previous examples of project-based approaches, show the limitations of one specific field in providing a viable solution on the long term, which is essential for sustainability.

It is crucial for the correct development of an international collaboration program to establish an open and continuous means of communication. Faculty must develop the sequence of actions that will help on framing the problem, to allow the students to actively participate in a broader project definition.

Challenges faced in the international collaboration.

No doubt the collaboration between institutions located in different cities, and moreover, in different countries, will challenge not only the ability to communicate between the members of the team, but also to recognize and adapt to the different cultures and ways to conduct of the participants[9]. In this case, we allowed a period of adjustment by having introductory meetings and lunch gatherings. The graduate student in computer science from the TecNM Leon carried out a three-month research visit to the UTRGV which allowed him an immersive experience in an US University. The scholarship was provided by his institution and the CONACYT. The Texas Southmost College and the UTRGV are located in the same city which facilitated the students from the first one to attend project meetings. The students and faculty from the TecNM

Matamoros were located just across the border from the UTRGV Brownsville campus which didn't represented too much problem either to attend work meetings. Nevertheless, students and faculty took advantage of social media and electronic tools to create group chats and virtual meetings to keep in contact regularly.

Designing an Effective International Collaboration

The collaboration scheme described in this work has a high content of student empowerment by motivating them to participate in conferences and poster competitions. It also let them figure out the best way to communicate by themselves and interact with their peers. Faculty facilitates meetings, resources and mobility, but even though, some of those resources come from funding where the students applied as a team or individually.

During the project, we took advantage of forums that promote student success such as those in the UTRGV, for example Engage scholar symposium, and NSF INCLUDES Symposium for advancing Latinas in STEM academic careers.

Participating in this type of project requires a lot of extra work beyond the classroom and the regular class assignments, therefore it is of utmost importance to invite students whose academic load allow them to devote the time that the project demands.

For faculty, the project selection has to be one that fits their field of expertise and in which they find professional development in the form of publications etc.

Outcomes of the Project

This project is a work in progress, however, we have had some outcomes to this date that exemplifies some relevant activities and outstanding achievements. The beginnings of this project in 2017, with the initial collaboration of UTRGV and TecNM Matamoros, permitted to obtain funding from *The 100,000 Strong in the Americas Innovation Fund* which allowed to build a solid foundation for expanding the project.

In 2018, a group of twelve students and three faculty participated in the annual conference of The Texas Regional Alliance for Campus Sustainability (TRACS) in Stephenville, TX, with posters and presentations of collaborative work in the fields of automation, energy, and sustainability. Some of these works were also awarded in the UTRGV Engage Scholar Symposium of the same year, due the quality of the technical content and results.

During 2018, witnessing the success of collaboration in the project, the UTRGV CECS, and the TecNM Matamoros signed a Memorandum of Understanding which was fundamental to expand to other projects with different departments, such is the case of the TecNM with the Mechanical Engineering Department and the College of Science.

In 2019, with the integration of a graduate student from TecNM Leon, the CONACYT recognized the importance of the aspects that have been discussed in this paper, consequently, awarded the student with a scholarship for the travel and research visit to UTRGV for three months.

Benefits of International Collaboration Project.

Based on our personal experience in industry and in the interaction with people from local companies in different forums, there has been long discussions about the importance of providing the students with additional set of skills to those traditionally thought in the classrooms. For example, sense of urgency to meet project deadlines, leadership and communication skills. Many companies nowadays are global and their employees have to Interact with individuals of different cities, cultures, and idioms. Through participating in this project, we help to develop skills that our students will need to succeed in their professional life. In the case of UTRGV, the strategic plan includes to positively impact our region with high level research, and international collaboration is a key ingredient for that, this project contributes to that goal as well.

Conclusion and Future Work.

In this paper, we described a challenging project not only in terms of technological advance but also in terms of coordinating collaboration with a group of undergraduate and graduate students from four different institutions in US and Mexico. We created a scheme to promote professional development in the students by giving them the experience of international collaboration, teamwork, communication and networking. This project is in progress and is expected to offer more positive experiences along the way to completion.

References

1. The University of Texas Rio Grande Valley http://www.utrgv.edu/en-us/

2. The University of Texas Rio Grande Valley - Engineering Technology program

http://www.utrgv.edu/_files/documents/admissions/undergraduate/dp-engineering-technology-bs.pdf

3. Zhou, Z. (2014, January). Managing engineering capstone design teams: A review of critical issues and success factors. In *IIE Annual Conference. Proceedings* (p. 3006). Institute of Industrial Engineers-Publisher.

4. Tee P.L.K., Goh S.K., Cheah K.S.J. (2015) Cross-Cultural Challenges and Synergies Working in an International Collaboration Project. In: Tang S., Logonnathan L. (eds) Taylor's 7th Teaching and Learning Conference 2014 Proceedings. Springer, Singapore

5. Carew, A. L., Wickson, F. & Radcliffe, D. (2006). Lessons from transdisciplinary studies in the design and evaluation of engineering education research. AAEE - Annual Conference of Australasian Association for Engineering Education (pp. 1-7). Auckland, NZ: Australasian Association for Engineering Education.

6. Kelly, Patricia (2006) *Towards Globo Sapiens : using reflective journals to prepare engineering students able to engage with sustainable futures.* PhD thesis, Queensland University of Technology.

7. Immanuel A. Edinbarough, Adriana Olvera, "Process Automation in Smart Environments: Intelligent Closet Prototype", *Proceedings of the 2018 American Society for Engineering Education* Conference for Industry & Education Collaboration, Feb. 7-9, 2018, San Antonio Texas.

8. Lake, Danielle (2012) Sustainability as a core issue in diversity and critical thinking education, in Bartels, K.A. Parker, K.A, (2012) Teaching sustainability, Stylus. USA, pp. 31 - 39

9. Edinbarough, I., Olvera, A., Pineda-Briseño, A. , Jesus Gonzalez (2017, June), "Social-cultural elements of cross-border collaboration in engineering undergraduate projects between UTRGV-ENGT and TecNM/ITM" Paper presented at the International Conference on Border Studies, October 25, 2017, Brownsville, Texas, USA.