Engineering Technology Capstone Projects: Microcomputer-Based Solutions

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Introduction

This paper describes the success examples of previous capstone projects, where the students were challenged to solve problems in technology development and smart environments. These examples provided the students with a team-based experience in the product design cycle, from research, design, parts fabrication, product assembly, to the implementation of microcomputer-based systems to solve a real-world problem, lowering the product cost, and obtaining a functional prototype.

The interest aroused by previous projects have led faculty and students to solve problems in other areas, such as building adaptation, technology development and innovation in manufacturing, using low-cost microcomputer based systems. The described activities evolve in a novel engineering technology education scheme, where multidisciplinary teams experience an undergraduate cross-border collaboration, which promotes international preparedness in engineering education.

Background

The University of Texas Rio Grande Valley (UTRGV) is a relatively young institution, created in 2013, and officially started operations in 2015; it was created by bringing together two of the most important regional institutions: The University of Texas at Brownsville (UTB) and The University of Texas Pan American (UTPA)[1], both of them with more than 30 years of experience in higher education. The new university is emerging as a regional research institution projecting to grow as a leader minority-serving research institution.

The UTRGV served the Rio Grande Valley, through the 150 mile-wide region, categorized as one of the fastest growing emerging metropolitan areas in the world, hosting diverse manufacturing industries. Located in southeast Texas, USA and northeast Tamaulipas, Mexico, this institution was created embracing the opportunity to serve a population of over 3.5 million people, amongst the border of Texas and Tamaulipas. *The new university was created with the mission to transform Texas and the nation through student success, research, healthcare, and commercialization of university discoveries*[1].

Diverse actions have been established to achieve the university mission, such as the development of a manufacturing regional training ecosystem, providing interesting opportunities for students at UTRGV and of different regional Colleges (Texas State Technical College and Texas

Southmost College), with the creation of the Manufacturing Innovations Hub (MIH) in McAllen, and recently the Manufacturing Innovations Hub (MIH) in Brownsville.

With an extensive selection of undergraduate programs in the engineering field, 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]. A clear example of this statement can be found in the Department of Manufacturing and Industrial Engineering at URTGV, within the Engineering Technology (ENGT) program, emphasizing primarily *on the applied aspects of science and product improvement, industrial practices, and engineering operational functions*[2].

As an effort to broaden its mission, UTRGV have created the Office for Sustainability, *which is working with faculty to gain awareness of conservation, embrace a culture of sustainability, and connect sustainable operations with the broader academic mission across departments and programs through positive teaching/learning experiences*[3]. In order to embrace sustainability factors in the curriculum, the Engineering Technology Senior Project I, and Senior Project II courses, have adopted ten out of the seventeen goals described in the United Nations Sustainable Development Goals[4], to provide the students with a broader opportunity to connect the activities that promote the community sustainable development: 2. Zero Hunger, 3. Good Health and Well-Being, 4. Quality Education, 8. Decent Work and Economic Growth, 9. Industry Innovation and Infrastructure, 10. Reduced Inequalities, 11. Sustainable Cities and Communities, 12. Responsible Consumption and Production, 13. Climate Action, and 17. Partnership for the Goals.

Higher education institutions have been assigned with the mission of contribute to global development and the expansion of knowledge, to impart the ethical vision and technical knowledge needed to ensure a high quality of life for future generations; therefore sustainable development should be the framework in which higher education set its sights[5]. It is within this context that the Engineering Technology program at UTRGV is working in capstone projects to advance in the fields of technology development, smart environments, and innovation in manufacturing, towards environmental, economic and social sustainability.

Methodology

The Engineering Technology program at UTRGV requires the completion of a capstone project, to be developed throughout two consecutive semesters, Senior Project I and Senior Project II. The project includes application of skills, knowledge techniques, concepts in the design and manufacturing. Emphasis is placed on project management, documentation, and presentation[2] of a completely functional prototype. Therefore, the elements of sustainability must be included on each project, since sustainability includes all the interrelated activities that promote the long-term flourishing of Earth's human and ecological communities[6], and one of the most important requirement for the projects is to address a regional need.

In order to achieve a capstone project in the fields of technology development, smart environments, and innovation in manufacturing, students are encouraged to promote a sustainable development approach, the solution must reflect an intimate connection among the research, a clear understanding of the impacts by reducing any negative ecological and social

footprint, and a continuous life-cycle analysis working to improve local and regional communities[7], to deliver a result that can be defined as environmentally responsible, economically feasible and socially conscious.

Successful cases of Previous Capstone Projects

Technology Development: 3D Printer

3D printing is an additive manufacturing technique in which objects are created by depositing layer by layer of materials to obtain a final product. The advantage is that material doesn't have to be removed to shape the final part, and therefore, the negative impact of manufacturing due to generation of scrap material is eliminated. If this technology becomes cheaper and more accessible, waste will be reduced in the manufacture of products. A low cost 3D Printer was developed by a group of students. This device has the same capabilities of a similar polymer printer commercially available. With the use of microcomputers and electronics of open source, and by innovating in the design and in the assembly, the students were able to reduce the fabrication costs dramatically.

Smart Environments: Intelligent Closet

Human physical activities can be supported with Smart Environments. The use of technology through sensors, instruments, computers and actuators can help to reduce the unsafe activities and assist in healthcare. Engineering Technology students developed an intelligent closet which organizes the garments in defined slots inside the closet that can easily be retrieved subsequently with the use of an HMI (Human –Machine-Interface). This type of devices can greatly assist the elderly and disabled and also to the operation of healthcare centers that need to manage large quantities of garments, reducing hazardous activities.

Innovation in Manufacturing: MQL

In the branch of innovation in Manufacturing, a group of students carried out a comparative study of different lubrication techniques during the milling process of soft steel. They studied the lubrication with Cold Air, with MQL (Minimum Quantity Lubrication) and the effect of combining bot Cold air +MQL.
The use of excessive cutting fluid is the most common method to control the temperature during machining, but it presents harm to the environment because the difficulty to be recycle and eliminated.

Current Capstone Projects

Technology Development: Additive Glass Manufacturing

Additive Manufacturing (AM) has drawn significant attention as it moves from rapid prototyping to the fabrication of production parts. Powder bed processes such as selective laser sintering (SLS) are among the most popular techniques for making complex three dimensional (3D) parts directly from computer aided design (CAD) models. Glass has a widespread such as windows,

optics (imaging and non-imaging), and hermetic seals. Glass creations is known to be complex in many manufacturing processes. Traditionally, glass powder is melted in a furnace, and cast in molds to form specific shapes. A group of students are focusing on designing and building and efficient and technological 3D Glass printer. The machine will be used to create glass pieces that will have all proper characteristics to be classified as a net shape.

Smart Environments: Corn Storage

It has been estimated that most corn grain storage units account for two percent grain loss due to naturally occurring environmental conditions that when adjusted, will allow to minimize the percent of grain losses. The purpose of this project is to create an internet enabled system that will allow for immediate visualization of temperature and humidity. Also, to control those parameters automatically to the optimum conditions to minimize grain losses. The system will use low cost micro-computers and electronics which will minimize the cost of the project making it affordable for small and medium size farmers.

Innovation in Manufacturing: Intelligent Monitoring of Chatter Control in Machining Processes

This project consist on the creation of an intelligent monitoring of chattering control to measure vibrations on the lathe turning machine while machining a work piece. A system based in Data Acquisition and statistical analysis will be designed and put it in place to automatically detect vibrations on the work tool and spindle and warn the operator to make the necessary adjustments to the process. The reduction of chatter will increase tool life, reduce maintenance cost, operation downtime and waste of parts and energy.

The results of the previous capstone projects and the objective of current projects contribute to generate sustainable processes in the fields of Technology Development, Smart Environments, and Innovation in Manufacturing.

Conclusions and Future Work

The projects defined during the capstone courses are developed with a sustainable vision in order to prepare them to excel in the workforce in the global context. Therefore, the Engineering Technology program has been working to strengthen international collaboration between regional leader higher education institutions.

With the proposed cross-border collaboration, the Engineering Technology program will be fostering United Nations Sustainable Development Goal #17 *Partnership for the Goals*, in its mission to serve the regional RGV community on southeast Texas and northeast Tamaulipas, in its developmental phase.

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