New Engineering Programs and University-Industry Collaboration in Engineering Education

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Abstract

When collaboration between Universities and Industries are the topic, one could ask the question "What is the nature and extent of collaboration on the industry side as it relates to engineering education?" Do companies assist with course instruction and in developing curriculum, or perhaps allow company access to students working on projects. Of course it could be all of the above. With the North American Free Trade Agreement (NAFTA) passing through congress, the border area of states neighboring Mexico became the center of economic activity, or what is known as a "Boom." As the border areas with Mexico grew and more money and resources were poured into these regions, the demand for a more professional labor population, technicians, engineers, and managers increased. Many US companies and manufacturer found themselves relocating entire factories, equipment, and warehouses. Relocating managers and engineers would become a bigger challenge and in some cases almost impossible.

This paper describes the collaboration between a higher education institution and several companies collaborating to educate and train their engineers and managers. This collaboration provided better student learning, synchronized project work for classes, company tours and involvement in learning, simultaneous final project reporting to company managers, and even financial backing from the companies involved for communication infrastructure and logistics. Obstacles and challenges that must be overcome to develop a program that is technically sound and in some ways is performing better than expected is described. This paper also discusses some of the difficulties facing faculty and administrators of such programs and presents various approaches that have been implemented successfully.

Introduction

A graduate program geared specifically toward the needs of the engineers and managers employed at companies called Maquiladora twin plants, is designed by collaboration between Texas A&M University and companies that mostly manufacture electronics, parts, and components for Automotive Industry [1]. The curriculum provides two integrated portions (Industrial & Electrical Engineering) based on design, testing, and manufacturing with respect to the knowledge base and application requirements of the companies. Most companies in this region are suppliers of the Automotive Industry.

Due to rapid increase in global competition for automotive sales and profitability, more and more auto makers pass the requirements of success to their suppliers. As a result, demand for leading-edge concepts in design, including Design for Assembly and Manufacturability, Concurrent Engineering, Reengineering Technology, Quality Control and Certification, and environmental requirements became the supplier's responsibility. These requirements, along with demand for technical expertise, provided the catalyst needed for a mutually beneficial collaboration between the University and the Industry.

As part of curriculum development, the administration and faculty met with the Maquiladora plant managers and leaders several times over a span of several months. The primary objective was to asses the technical, educational, and administrative support required to keep up with the forecasted growth of the twin plants and to establish a long-term goal based on the future of manufacturing in the area [2]. The secondary objective was focused on the type and level of collaboration needed to make this a successful project. The first challenge was to establish a curriculum that would be broad and multi-disciplinary, while satisfying the individual plant's requirements, the department requirements, and the university resources available for a long distance educational program. Lack of resources as far as facilities, classrooms, and even the faculty members to support the proposed curriculum, were some of the challenges that the college of engineering was facing.

Industry and Collaboration

The companies that bought in the idea of this collaboration agreement were mostly companies that recognized the need for both short and long-term advanced technical expertise. After months of negotiation, the collaboration agreement resulted in development of the following guidelines.

On the university side:

- The university would provide a Masters of Engineering degree program, identifying course curriculum, scheduling, and all requirements toward receiving a master's degree from the institution.
- The university would provide two courses in each discipline every semester.
- The courses would be scheduled to be offered after-hours on Fridays and all days Saturdays for engineers and managers accepted to the program.
- The degree curriculum would be designed so students could join the program at any time.
- Classes would be conducted geographically at a central location that would serve all companies within the agreement or on campus until distance education delivery was implemented. This central location would end up at the Texas A&M Research Extension Center.
- The institution would agree to provide tuition discount to the qualified foreign engineers working at the companies to include paying in-state tuition for all participants.
- The department would allow students to base their class projects on projects that they were involved in at the time in their respective companies.

- The department would also allow final projects to be related to company projects after review and approval by the graduate committee and the student's engineering supervisor at the company.

At the company side:

- The companies would identify qualified candidates for this Masters of Engineering degree from their pool of engineers and managers.
- The companies agree to pay the student's entire tuition and cost of books provided that the student is accepted to the graduate college and the department and receives the in-state tuition discount from the university.
- The company also stipulated in providing space for class meetings at various plant locations as the need arises.
- The companies would provide access to faculty and students working on projects for completing class projects or student's final project.
- Companies would allow access to hardware, software, technology and provide technical assistance toward completion of assignments and projects.
- The companies would also raise money to build a T1 tower for teleconference delivery of instruction to various sites at the industrial parks and provide additional funds for audio and visual teleconferencing equipment for instruction delivery.

The Program Kickoff

The program started with faculty traveling over the weekend to one of the plants centrally located and lecturing Fridays and Saturdays. To meet the goals set by the companies, a set of features were set forth for the curriculum development. The main objective was to have a program that provides a sound technical knowledge and solid background in the following areas:

1. Mathematics
2. Computer Information Systems
3. Computer Aided Design in Electrical Engineering/Electrical Engineering
4. Computer Aided Design in Industrial Engineering/Industrial Engineering
5. Manufacturing Process, Quality Control, and Safety
6. Economic awareness and Management Science
7. Research project in a major area

Keeping these features in mind, two independent and yet integrated curriculums were developed [3]. Table 1 illustrates the curriculum model for Electrical and Industrial Engineering degrees. These two programs combined provided 95% of the technical knowledge and expertise the companies needed to stay competitive and self supporting from the technology stand point. The curriculum consisted of two main segments: Masters of Engineering in Electrical Engineering and Industrial Engineering. The Electrical Engineering branch consists of seven specific courses in two major areas, Electronic and Control. The Industrial Engineering branch also consists of seven specific courses with emphasis in Manufacturing, Design, Operation

Research, Ergonomics and Safety. The engineering economics, computer science, and manufacturing components were shared in both curriculums.

Besides the general prerequisites, essential courses for a specific discipline and research project are also required. For a student to graduate from the program, he or she must follow the steps outlined in Figure 1 [4]. With a B.S. degree in engineering, grade point average above 2.5, Graduate Record Exam (GRE) scores of 1000, and an English proficiency exam such as Test of English as a Foreign Language (TOEFL) of 525, a student could be admitted to the program. The students may begin the two-year program upon full admission at any semester along the two years scheduled program, assuming that they have the necessary background or experience to begin without taking any pre-requisites.

Table 1: Curriculum and Contents for the Two Masters of Engineering Programs

INDUSTRIAL ENGINEERING	ELECTRICAL ENGINEERING
Advance Engineering Economic Analysis (6)	Advance Engineering Economic Analysis (6)
Advance Numerical Methods (1, 2)	Advance Numerical Methods (1, 2)
Computer Appl. Statistical Methods (1, 4)	Dynamic Systems I (1, 3)
Principles of Optimization (1, 3)	Digital Computer design (2, 3)
Ergonomics (4)	Control Systems Synthesis (1, 3)
Computer Simulation Industrial Systems (4)	Electronic Systems Design (3)
Database Systems (2)	Database Systems (2)
Manufacturing Systems Design (4, 5)	Manufacturing Systems Design (4, 5)
Activity Scheduling (4, 5)	Electronic Circuit Design (3, 5)
Computer Integrated Manufacturing (4, 5)	Computer Networks (2, 3)
Systems Safety (4, 5)	Systems Safety (4, 5)
Research Project (4, 7)	Research Project (3, 7)

(1) Mathematics
(2) Computer Information System
(3) Computer Aided Design/Electrical Engineering
(4) Computer Aided Design/Industrial Engineering
(5) Manufacturing Process, Quality Control and Safety
(6) Economics and Management Science
(7) Research in Major Area

Program Coordination with the Companies

During the first year of this program, classes were held at the twin plants located in Reynosa, Mexico. They were later relocated to Hidalgo, Texas, a small town by the border immediately north of Reynosa. Exploring the challenges involved in distant learning reiterated by the brevity of resources, and yet planning to maintain a quality and successful program was the issue to be addressed in the near future. The most logical and economically feasible solution to the distant learning was the use of Trans-Texas Video conference Network (TTVN), with 15 sites within various Texas A&M University system facilities all across Texas. This technology provided the state-of-the-art digital interaction video conference and distant education capabilities. Two-way visual/verbal communications links to all Texas A&M system university campuses and facilities in Texas.

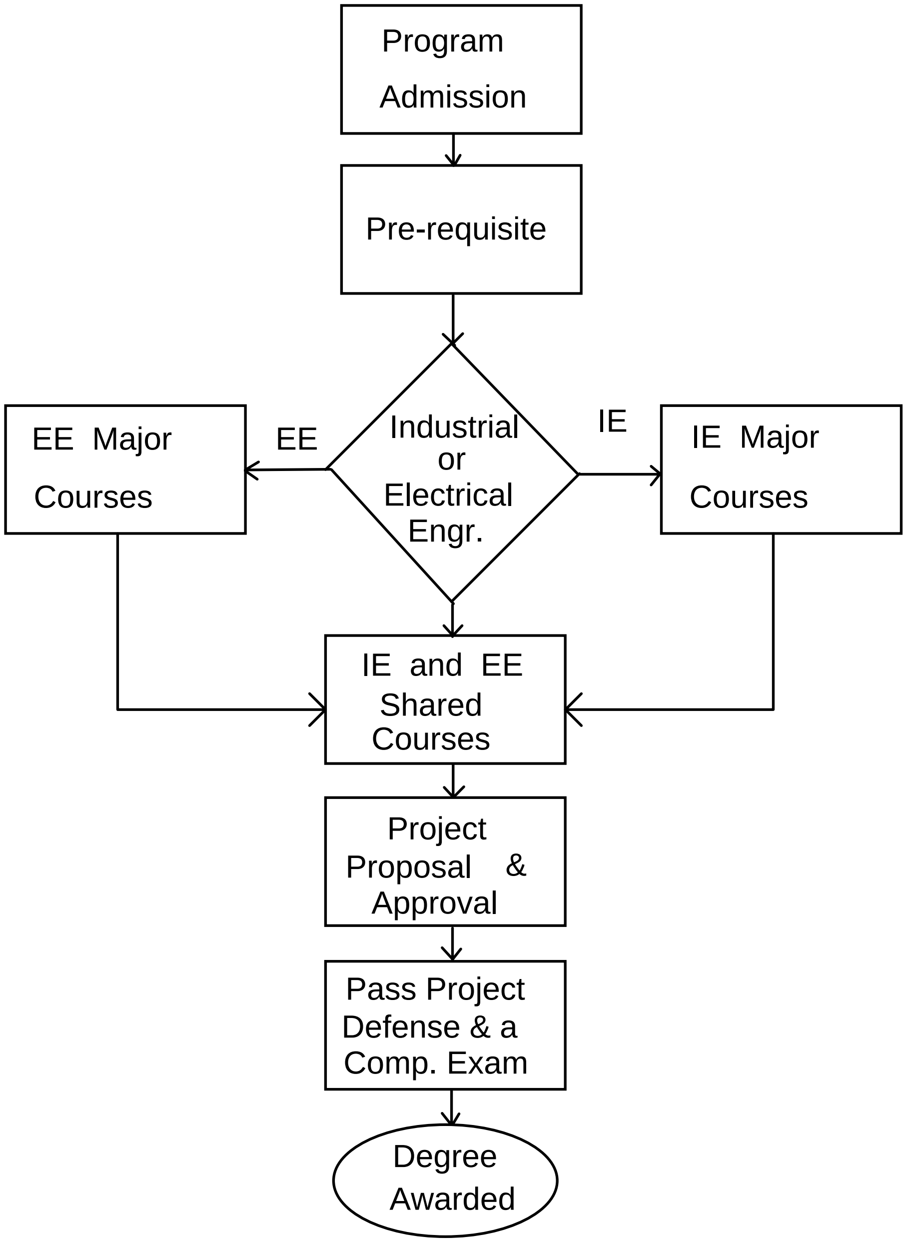

Figure 1: Program Flow Chart

Since 1990, TTVN system has been used for one-half of the total teaching time. The faculty and the students must meet at one location at least 1/2 of total class time. To meet the course objectives, when using TTVN as a teaching medium, a strategy must be used to not only cover the course content but also create the necessary interaction with the students. From a total of sixteen lectures per semester, four are taught on campus and another four are presented at Weslaco, Texas, serving the south Texas border areas between Laredo and Brownsville Texas. Weslaco is the home to Texas A&M University Agricultural Research and Extension Center and is located centrally to all major cities in south Texas.

The dynamic schedule and the rotation of meeting locations, in combination with changing instructional mode, have become a challenge for the faculty and students. Other contributing factors include language differences and multi-cultural personalities between students, faculty, and staff. Time differences and national and local holidays between the two countries include some of the logistical problems that remains discrepant.

Using the TTVN system as a teaching media is a challenge of its own. It requires at least several semesters and a few training courses for the faculty to become familiar and comfortable with the system. The same challenge is bestowed upon the students as well. They must be motivated enough to achieve the level of concentration required, especially in highly technical and advance classes. The dedication and the level of commitment are higher for the students, faculty, and administrators, as it would be for a traditional on campus program. Students are instructed in a technology classroom using TTVN.

Figure 2: TTVN Classroom

In addition to a work load which averaged around 50 hours per week for most engineers and managers from the Maquiladora companies, they were now attending classes six (6) hours per week and commuting to class location or campus for an average of 2.5 hours per week. This does not include the class preparation time, time required to complete homework and other assignments, and time needed to coordinate project work and activities which averaged around 5 hours per week. Many companies realized that this additional time-tax of around 13.5 hours per week on their employees would be justified if there is a complete emersion and interaction of educational activities and company activities within different projects at various department or divisions. Many of the students would move from project to project or change assignments following their course curriculum and topics. This again brought a better understanding of the course topic and its application to the real world and company projects and provided for lively discussions and even free consulting or faculty opinion from the classroom.

The Collaboration on the Final Projects

Each student, after completing all courses, is required to complete a research project to receive the masters of engineering degree. The research projects are tied or derived from existing problems or ongoing projects in the company where the students are employed. Identification of the problem is performed by consulting the manufacturing management. The proposed research project must then be approved by the members of the research project committee. The faculty advisor guides the student in deriving at a state-of-the-art engineering solution. After the completion of the project, a formal report and a presentation and defense for the project are due. Many successful projects have been taken up by the students and their faculty advisor. A short list of project topics at various companies is provided in Table 2. The procedure is very similar to a normal on campus Masters program. The main difference lies in the selection of the research project. The research project can be individual, departmental, or company-wide projects that the students are currently involved with at various levels and capacity.

The interaction experience in the classroom between the students, faculty, and student-faculty was tremendous. The interaction was at all levels-cultural, educational, technical, and intellectual. The students brought their companies and their projects and challenges into the classroom and it seemed that there was never enough time for these in-depth and interesting discussions. It was also apparent early on that the students were getting much more than a traditional Masters of Engineering classroom exposure and experience. The feedback to their companies was overwhelmingly positive and reassuring.

The project topics and the extent and the depth of the study would be based on the company's assignment of the student engineer to a specific project. In some cases, engineers would be participating in the program just so they would be assigned to a project critical to the success of the company. Some project reports could become more complex than a thesis or dissertation. Occasionally students were allowed to select topics not related to their companies' activities. In all cases, both the company and the faculty graduate committee must approve the project topic. In many instances, as part of this collaboration effort, companies would allow students to utilize company resources such as hardware and software or even access to technicians, mechanics, or machinists. In all cases, the final report presentation would be to both University faculty and students and members of student's organization or company.

The companies soon realized that along with their engineers and managers getting an advanced engineering education and technical knowledge, they also have access to additional high-level expertise of the faculty when needed as consultants. This became even more prevalent after several years when many of the program graduates were promoted to higher positions within the companies. Some even became industry leaders and entrepreneurs and started their own companies with great success, and some became chief engineers or plant managers.

Table 2: List of Various Projects at Different Companies

1. "How to Design and Implement a Quality System to be in Compliance with ISO 9000 Quality Standard Series", Johnson Controls-Mexico.
2. "Computer Simulation and Animation of the Operation at Deltronicos Using WITNESS", CMM-Mexico.
3. "Development of an Expert System to define Physical Work Requirements", Zenith-Mexico.
4. "Just-In-Time Purchasing in a Manufacturing System", Delphi.
5. "Accelerometer Transducers Calibration Using LabView Software as an Automation Option", Breed Automotive-Brownsville, TEXAS.
6. "Computer Simulation Model To Assist In Information Management And Emergency Evaluation In The Texas Coastal Area", GM-Brownsville, Texas.
7. "Ergonomic Guide to Improve Productivity and Quality", Calidada Electronics-Brownsville, Texas.
8. "Design and Implementation of an Accelerated Business Plan", Lucent Technologies-McAllen TEXAS.
9. "The Calcination of Sodium Altimonate Glass Grade E to be used for Manufacturing of TV Glass Screens", Enron-Laredo, TEXAS.
10. "Utilizing Identification Matrix for Shop Floor Tracking: A New Manufacturing Technology for Product Identification", Breed Automotive-Brownsville, Texas.
11. "Practical Approach to The Implementation of an Environmental management System", Delco-Electronics-Mexico.
12. "Computer Simulation Applied to the Manufacturing Industry", Delto Electronics-Mexico.
13. "Implementation of a Lean Packaging System", CMM-Mexico.
14. "Evaluating the Effects of Temperature on Physical Work Performance", Valeo Automotive-Detroit, MI.
15. "Analysis of the Application of Design for Assembly to an Electro-Mechanical Device", Deltronicos-Matamoros, Mexico.
16. "Impact of Kanban Systems on a JIT Manufacturing Process", Deltronicos-Matamoros, Mexico.
17. "Hazard Tasks Assessment in Sand Molds Preparation in an Aluminum Foundry Plant", Reynosa Foundary, Mexico.
18. "Implementation of Reliability Centered Maintenance (RCM) in a Manufacturing Facility", Delphi Automotive, Mexico.
19. "Lean Manufacturing in a Magnesium Die Casting Facility", DISM, Mexico.
20. "Total Productive Maintenance Implementation in a Manufacturing Environment", Global Data Solution, Hidalgo, Texas.
21. "Ergonomic Evaluation of A Steering Wheel Leather Wrapping Process ", Delphi, Mexico.
22. "Optimization of the Electrical Design Process in the Automotive Industry", Deltronicos, Mexico.

Conclusion

The program is able to react to fluctuation in the regional demand for education and changes in NAFTA policies along with global economic outlook. As more experience is gained, a more flexible approach to University-Industry collaboration and interaction is utilized. The feedback from the students, graduates, and the participating plant's management has marked the success of this program. Similar programs have started at other higher education institutions mimicking this program but placing focus on short term technical support or training and not a degree-offering program with substantially developed curriculum.

References

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Biography

KAMBIZ FARAHMAND is currently a Professor and department head at the Industrial and Manufacturing Engineering and Management at North Dakota State University. He is an internationally recognized expert in Productivity Improvement. Dr. Farahmand has over 23 years of experience as an engineer, manager, and educator. He is a registered professional engineer in the state of Texas and past president of IIE Coastal Bend Chapter.