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BRIDGING ACADEMIA AND INDUSTRY GAP, THROUGH GLOBAL COMPETENCIES: INDUSTRIAL OUTREACH PROGRAM US-MEXICO

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ABSTRACT

Global competencies of engineering graduates have been identified as traits that are increasingly necessary for professional competitiveness of graduates, but continue to be elusive and difficult to address in the engineering curricula. Study abroad and experiential learning programs have been invoked to address some of the global competencies with varied degrees of success. In this paper, a faculty-led program model developed by West Virginia University and several institutions in Mexico and the US is presented, in which senior engineering students from the US and Mexico team up to conduct meaningful engineering projects in industry in Mexico. Intermixed teams of students are formed and placed in various industrial sites to work full time under the advice of engineering practitioners and faculty members from both Mexico and USA. Global competencies are addressed in the context of a project that requires students to work with peers of similar disciplines and level across language and cultural barriers.

INTRODUCTION

Global competencies in engineering education have received significant attention recently and have been described by various authors in somewhat similar ways, Hunter [1] (Numbers in brackets designate references listed at the end) and Widmann and Vanasupa [2], among others. They typically deal with skills that are necessary to successfully conduct professional business abroad or with professionals from different cultures. One definition of a globally competent engineer by Downey et al. [3] is one who is capable of working effectively with people who define problems differently.

The Accreditation Board for Engineering and Technology, (aka ABET), in its accreditation criteria EC2000, makes a reference to the global context of engineering education in its outcome h, which was recently assessed by Sanchez [4] making use of global competencies. In all cases these definitions are consistent with the taxonomy of significant learning developed by Fink [5] in which global competencies are classified in three broad categories of knowledge, skills and attitudes.

A breakdown of abilities and competencies addressed in the Program described here is given in Table 1 below, which is an expansion of Finks Taxonomy cited above. In this expanded Table, a combination of skills and abilities acquired through both traditional education and experiential learning is presented. While much actual learning takes place in a school environment, experiential learning can only take place in actual professional settings. This Program aims to address dimensions 3 to 6 in the table, making use of dimensions 1 and 2, while promoting awareness of dimensions 7 and 8 on the table.

ACADEMIA AND INDUSTRY CULTURES

Bourdieu [6] describes academia as perhaps as one of the most conservative and traditionalist institutions. Industry on the other hand is a changing, progressive and adaptive entity, in which the measures of success are more related to conducting business effectively in spite of local, national or global competition, as per Chu-Carroll discussion [7]. Effective team-work, timely delivery, client satisfaction and ultimately business sustainability are at the core of the measures of success in industry.

Industry has come to master the concept of client-supplier relationship through a product in order to attain business sustainability. The relation between Academia and Industry similarly hold a client-supplier relationship in which the academia is the supplier, industry is the client and the graduate is the product.

The Program model presented here aims to bridge the gap between the environments of academia and industry in a manner similar to that presented by Sneed [8], with the added element of an international professional immersion. In doing so it is essential for faculty members involved to relate to the industrial culture, not typically concerned with publications and typically very protective of information confidentiality. In addition, the time dimension in industry does not comply with and academic calendar and the schedule of tangible deliverables becomes the key driver of the industrial practice. Understanding of this from the onset of the activity with any industry is the key to the success of the program herein described.

DESCRIPTION OF THE PROGRAM

Objectives of the Program

The basic premise used o set forth the objectives of this Program is that all participants must be able to draw a benefit. Since the main stake holders are students, industrial practitioners and faculty members, three main objectives are defined as follows:

1. To add value to the education of engineering students through an experiential learning activity with an international component.
2. To solve meaningful engineering problems of value to industry.
3. To share experiences and capacities between engineering practitioners and faculty advisors.

Sensibility in the Workplace

An essential element that is necessary in this Program is sensibility and deference to the workplace environment.

1. Thou shall not waste anybodys time.
2. Thou shall not stand in anybodys way.
3. Thou shall not pass unnecessary stress to others at work.
4. Thou shall not bore anybody.

Preparations

This program is aimed at graduating seniors in mechanical and aerospace engineering during the last summer they spend in their respective programs. The program runs for a six week summer session preceded by recruiting and preparation meetings during the fall and spring semester prior to the six week experience abroad. Eligible students must be in good standing and must be willing to participate in the preparation exercises

Course Pre-requisites

Students to be eligible must be seniors in good standing, with the idea of having participants who possess sufficient engineering fundamentals and skills to address practical engineering problems, with a clear opportunity to contribute to the solution. Typically participant students are within one year of graduation.

Weekly Reporting

Students are tasked to organize a plan of activities with a timeline which includes a system and problem description, a list of objectives for the project and a task-time distribution amongst the team members. This work is done in consultation with the industrial liaison and with the involvement of faculty advisors, who assist in the definition of the scope and depth for the project. While students work full time during the week, every Friday afternoon the entire group of Mexican and American students from all companies gather at a designated conference room to give a brief oral audiovisual presentation to the rest of the group on the progress made on each project. A caveat is that this presentation is to be conducted in the language of the other country. Students are aware that fluency in the other countrys language is not expected, however a best effort is expected by all the participants.

TABLE 1. DIMENSIONS OF ABILITIES AND COMPETENCIES ADDRESSED IN THE WVU-QUERETARO INDUSTRIAL OUTREACH PROGRAM

Dimension	Description	Personal Trait	Competency	
Fundamental knowledge	Understanding and remembering facts, concepts and information. Engineering issues and the fundamental theory is invoked and used in the context of the project at hand.	Knowledge	Competent Knowledge	
Ability to use tools	Ability to use tools and methods to understand solutions. Engineering tools requiring the engineering background to use them are required in all projects.	Know how		Traditional Learning
Applications Skills	Critical and practical thinking, creative use of knowledge to achieve solutions. Effective use of resources, time and capacities that require identification of critical issues and actions.	Engineering Skills	Effective Skills	
Integration skills	Connecting ideas, people, knowledge and resources. Teamwork, effective planning time and communication management are necessary to function and deliver.	Management capacity		
Professional Dimension	Understand role of the profession in a global societal context, appreciate the value of professional discipline and ethics inside and outside the workplace.	Attitude	Professional Attitude	
Human Dimension	Self discovery, values, interests, feelings, cultural appreciation and awareness. Empathy and sensibility for own and others cultures.	Sensibility		Experiential Learning
Self-drive to learn	Developing the habit of Life-long learning stay current on contemporary issues in both professional issues and how they relate to the global society.	Habits	Competitive Leadership	
Desire to Succeed	Willingness to make a difference and to make a contribution to society. Identify a sense of professional purpose and develop a mid-term and long-term professional vision	Self-Drive		

Advisors Role

Faculty advisors role is essential to the success of this program. They adopt several roles; advisors, facilitators, and in many cases mediators and consensus builders between team members. The challenge is to bring a non-intrusive presence to each group that allows students to work as independently as possible and to connect with the industrial liaison in carrying out the work. The team cohesion and bonding between industrial liaison, students and faculty advisors is critical for the attainment of objectives of this Program. Cultural acceptance of this program in industry rests heavily in the faculty advisors capacity to connect with industrial liaisons and student team to render seamless group dynamics.

TYPES OF INDUSTRIAL SITES INVOLVED

The type of companies that have been involved in the previous 15 years can be grouped in three main categories (with some examples given) as follows:

1. Manufacturing plants in the automotive industry:
   (a) Tremec, manufacturer of automotive standard transmissions
   (b) Spicer, manufacturer of commercial vehicle transmissions
   (c) CNH, manufacturer of agricultural tractors
   (d) Arvin Meritor, manufacturer of automotive aftermarket parts
   (e) VRK Automotive, manufacturer of automotive aluminum structures
2. Technology development centers:
   (a) Tremec, technology development for geared transmissions
   (b) CIDEQ, technology development for an industrial conglomerate
   (c) CIATEQ, national technology development and design center
   (d) GE-CIAT, GE advanced technology center for turbomachinery
   (e) In-Mec, technology development for CNC machines
3. National Research Laboratories:
   (a) CENAM, national metrology center
   (b) IMT, transportation research institute

In all these industrial sites, different types of professional environments are typically made available to student groups, so that they can contribute the solution to a given problem. Projects may deal with actual mechanical design of components or systems, in some other cases with trouble-shooting of mechanical systems in which performance simulation or testing is required. Others deal with design evolution or change and technology adaptation and integration, in which engineering issues are addressed, resolved and reported.

HOW GLOBAL COMPETENCIES ARE ADDRESSED IN THE PROGRAM

Lets start with people who define problems differently. Two adages apply; a good problem definition is half of its solution and garbage in, garbage out. Often in engineering practice problems arise, but are people who formulate or postulate what the problem is. A problem definition thus often carries a scope that reflects the perspective of the people who define the problem. Different perspectives may come to the forefront such as, functional performance, cost, reliability, marketability etc., together with a timeline and the resources associated with the problem at hand. In this Program, problems for the student teams are first proposed by the participating companies and in most cases, the problems are rather general and without specific bounds. For example; reduce the consumption of energy of a domestic appliance by a 5%, or reduce the noise levels of an automotive transmission, or measure the surface tension of a fluid. These problem statements are very general and elucidate a series of discussions on where to start and what to look for in terms of information and outcomes to produce. In this Program, teams of people with strengths in different areas such mechanics, manufacturing, mechatronics and design are faced with the same problem, thus various perspectives come forward. To further complicate matters, engineers from industry and faculty advisors may view the problems from quite different perspectives. In this Program this is common and it is both a challenge and an opportunity.

Next is the ability to effectively conduct team work with people of different backgrounds and cultures. A good group dynamics in this Program is key to success. A group that brings forward the strengths of each member to formulate, solve and present its solution is the aim in this Program but is far from being the typical and natural scenario. The contrary is true, teams often need a leader who can get things organized and moving in directions that will produce actual progress. Personalities are very important in this, patience vs. impatience, impulsiveness vs. shyness produce a work environment sometimes conducive to cohesion in the group and sometimes divisiveness in the group. Faculty advisors are the key to prevent this from happening providing focus and mediating to compromise and render functional groups. At the end, all benefit from a good team performance.

Next is the ability to communicate effectively despite cultural and language barriers. This is perhaps one of the best aspects of this program, students are forced to communicate with students who have the same level, but who speak a different language. In fact, all students are forced to speak the other country language and show a best effort in doing this. US students are required to access technical information written in Spanish, and are also required to make their power point presentations with bullets and captions in Spanish, while they can use English to carry out discussions. Mexican students are also required to make their presentations in English and using Spanish only when they have exhausted their communication capability in the other language, typically producing peer-communication assistance within the group. At the end of the six weeks, the effectiveness of communication across the language barrier is very noticeable.

Next is the ability to adapt and be sensible to different environments and diverse cultures. This aspect is a must in this Program. Cultural adaptability becomes a survival skill when students are in a totally foreign environment. From basic personal needs to technical traits a culture is present in the way people asks for things and the way people responds to inquiries and requests of information and services. Communicating a sense of respect and appreciation to others work is essential in effectively.

Finally the ability to identify and resolve cultural conflicts that have an impact in the professional work. This is an elusive ability that cannot be taught except in a contextual manner and the instances of opportunity occur only spontaneously in the field. While engineers excel in working under pressure, it is that pressure that makes cultures and personalities come to the forefront and provide both the challenge and opportunity to overcome through interpersonal and communication skills.

SAMPLE PROJECTS

Project at CIDEC (ConduMex)

In this project, students worked on the modeling, design and analysis of a cryogenic pressure vessel for liquid nitrogen to be used in the operation of a superconductor system (Figure 1). The emphasis was placed on the mechanical design of the vessel under thermal and mechanical loads.

Cryogenic temperatures and high vacuum pressures pose special design integrity challenges which require both computational modeling as well as experimental testing to be performed in order to determine realistic conditions of operation for the complete system. This project was in fact a follow up of the previous years project which is now in operation at an industrial site in Queretaro. The student team was comprised by one student from WVU, one from Clemson one student from CICATA and one from Queretaro Tech. They worked under the advice of CIDEQ engineers and faculty advisors.

Project at VRK Automotive

In this company, aluminum and steel structures and components for automotive applications are manufactured and assembled. High efficiency and quality requirements of various component designs require the use of advanced manufacturing systems including automated manufacturing cells. For proper quality production, several jigs and fixtures are often needed. The team in this company designed and tested various devices to provide

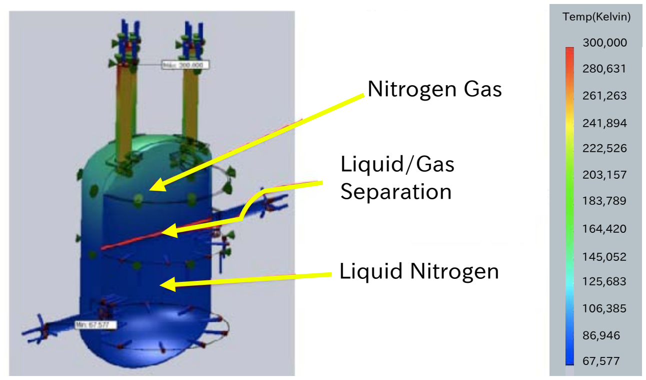

FIGURE 1. SUPERCONDUCTOR DEVELOPMENT AT CENTER FOR RESEARCH AND DEVELOPMENT OF GROUP CARSO IN QUERETARO

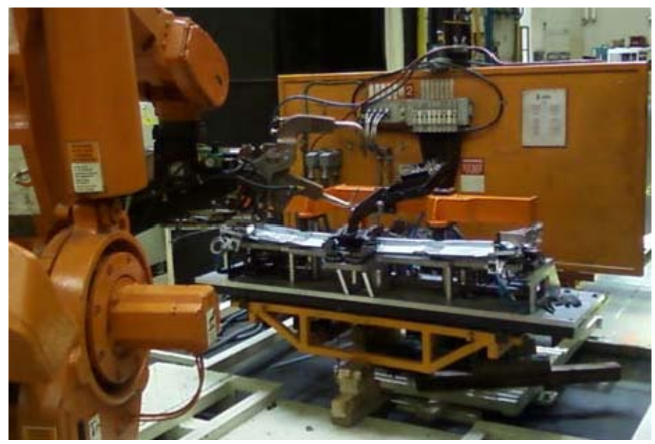

FIGURE 2. WORK CELL AND FIXTURES FOR WELDING OF ALUMINUM AUTOMOTIVE STRUCTURES AT VRK

quick and accurate-position fixation devices for a computerized manufacturing cell, Figure 2.

The team also produced the design of a mechanism for a special tool-handling system considering human factors to improve quality of product, reduce stress on the worker and increase the life of the tool. In this project two students from Clemson University (CU) teamed up with one student from ITQ (Queretaro State Technology Institute) and one student from ITESM (Monterrey Technology Institute) under the advice and supervision of VRK Engineers and faculty advisors.

Project at the National Metrology Center (CENAM)

This project developed at CENAM, The National Center of Metrology in Mexico (equivalent to NIST in the USA) involved the design of an apparatus to measure surface tension of fluids. The challenge was to design a system for measuring the surface

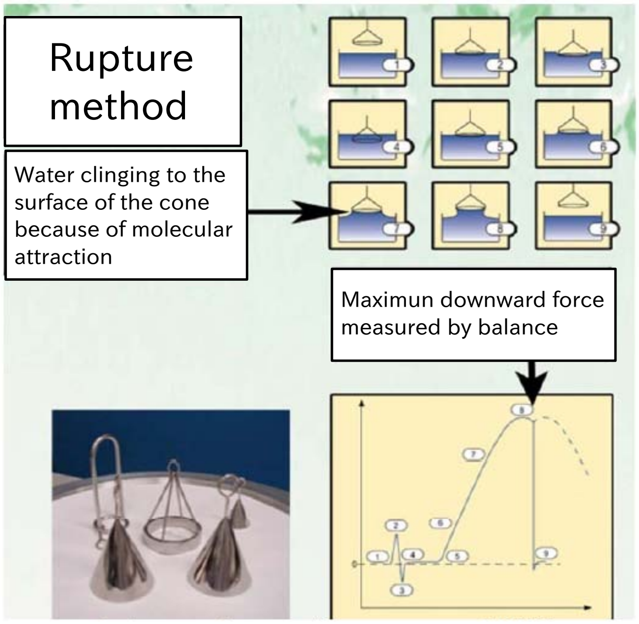

FIGURE 3. ELEMENTS FOR SURFACE TENSION EXPERIMENT SETUP AT CENAM

tension of fluids with improved accuracy as compared to currently used methods and at a fraction of the cost of commercially available systems. The team actually designed built and tested a measuring device which substantially improved the accuracy of the measurements at a small fraction of the cost of a commercially available system, Figure 3. This team was comprised by one student from WVU and one from ITESM who worked under the advice of researchers from CENAM and faculty advisors.

Project at CIAT (GE-Aircraft Engines)

One project was developed at GE Aircraft Engines at the Queretaro Site. The problem involved the finite element modeling and vibration analysis of tubing elements used in turbine engines. The main objectives was to determine the dynamic response of these tubes within the operation range of engines.

The finite element models developed provide a useful simulation of vibration response that can be used for effective fixation and bracketing of tubes and for potential damage analysis. In this project one student from WVU and one from UAQ (Queretaro State University) worked under the advice and supervision of one GE Engineer and faculty advisors.

LESSONS LEARNED

Students

The main beneficiaries of this program are the participating students. Both Mexican and US students draw direct benefit from this experience by direct exposure to industrial meaningful projects and by the cultural encounter with students from the other country. Students for the most part bring with them both the naivet of a young engineer in training, but they also bring the fresh eye and unbiased perspective to the forefront of an engineering problem solving activity. They go through the full gamut of cultural experiences that involve the professional and social aspects. Both sides (Mexico and USA) experience an intense cultural encounter, as they are somewhat unfamiliar with the other culture, let alone in an industrial site. As they are forced to use the other language to communicate, they face the stress of getting across effectively to get things done and they also enjoy the close exposure to the other culture through their own peers. Typically immediately after the whole program is completed, students often make remarks about how much they think they learned and how much fun the whole experience was. After few years, former participants actually have a different perspective and become more appreciative of what their participation in the program has meant professionally.

Industrial Firms

One of the key objectives of this program is to work on projects of value to industry. This objective can be attained in the measure that industry provides meaningful problems to the groups in which they have a vested interest. While the Program does not offer cheap labor, there is a clear intent to work diligently to solve problems of value to industry, to provide students both a challenge and opportunity to apply engineering skills and to learn in a contextual application. Industry also benefits from the network of professionals and institutions, which sometimes provides access to information, tools or equipment not readily available to industry. Yet the most valuable contribution that industry has offered to the Program is trust. Program participants experience (some for the first time) the responsibility of having access to confidential information and become aware the ethical and professional expectations. This is an invaluable lesson for all involved.

Faculty Members

It is obvious that faculty members have also drawn benefits from the close encounter with industry produced by this Program. From exposure to new technologies to new engineering cases to illustrate engineering concepts in the classroom are some of the direct benefits. Another important benefit for participating faculty members is the opportunity for an extended professional network including faculty members from other institutions as well as practitioners from industry, who learn about the skills and capacities of faculty members that otherwise, may go unnoticed by people in industry.

Universities

Various institutions have participated in the last 15 years. In general, local institutions have gained visibility in the local industry scene. In addition, local institutions have had the opportunity to establish further collaborations with the US institutions outside this Program. Meanwhile, visiting institutions had gained much in the international education arena. One aspect that is still a challenge is to give participating students equivalent credit at Mexican institutions as students are given in US institutions. Mexican students get only partial credit towards a practicum requirement, which does not require a grade. US students on the other hand get credit for a required capstone design course plus a technical elective course. Yet, it seems that the key factor to engage Mexican students is a positive group dynamics and realistic, feasible and challenging engineering projects.

State Government Agency

The Council for Science and Technology of the State of Queretaro (CONCyTEQ) has been involved in several initiatives to reach out to the private sector and the industrial community of the State. This Program is consistent with the mission charter of the Council and has provided an additional mechanism to identify local talent as well as to opportunities for synergy between local industry and universities. The Program provides in-kind support in the logistics of this Program, which is essential to make it work. Project solicitation to industry, housing for foreign participants, transportation and day-to-day operation is supported by the Council.

Interpersonal Communications Skills

Finally one last lesson learned involves the capacity of all involved to communicate effectively while under pressure and clearly outside the comfort zone. A difference must be established between assertive communication projecting self assurance and aggressive communication projecting frustration; while on the other hand, it is important to distinguish the difference between being respectful and being shy or timid. In general in this Program, good results come about with assertive yet respectful communication while aggressive and timid behaviors typically often produce unnecessary stress.

CONCLUSIONS

This Program is unique in the USA and Mexico. It pursues the main objective of adding value to engineering education through the development of global competencies, acquired through a meaningful engineering project in an international professional setting, providing an exhilarating full cultural immersion.

The Program addresses issues that range from communication skills and cultural differences to human relations in the context of a practical project that requires engineering skills. This experience has brought forward not only the practical engineering dimension and technical skills, but also the human dimension that comes with the territory.

A relationship of client-supplier between industry and academia can be effectively implemented to produce graduates with global competencies, as is the intent in this Program. This requires a commitment on the part of both academia and industry, which can be facilitated through local development agencies.

The international dimension in engineering education has acquired an added significance in todays globalized economy. Many major and midsize industries have rapidly expanded their industrial operations beyond borders, and it is more likely than ever, that engineering graduates will have to deal with professionals from different cultures in the job place. In todays industry, being able to understand and moreover anticipate cultural differences and may possibly make the difference to attain success in professional business.

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